Identifying, estimating and correcting the biases in WTO rules on public stocks: a proposal for the post-Bali food security agenda

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Abstract
In this paper, we analyse the WTO rules that specify how the subsidy provided to farmers by public stocks should be estimated. We identify three biases in these rules:
- Bias B1, resulting from the use of a fixed past unit value of imports or exports as the external reference price, instead of the *current* price cost of imports or exports.
- Bias B2, resulting from the use of the public stock procurement price instead of the price prevailing on the domestic market to estimate the price support received by farmers selling their production on the domestic market.
- Bias B3, resulting from the use of total national production instead of the marketed share of national production, thereby ignoring farmers' self-consumption.
The effect of these three biases on the estimated subsidy varies from country to country, but on average, WTO rules result in the subsidy being overestimated by a factor of between 2 and more than 300, depending on public stock intervention modalities and country characteristics. This means that in the most favourable scenarios, the estimated subsidy is (on average) twice the real subsidy.
These biases have a huge effect on country compliance: many countries have an estimated subsidy that exceeds their maximum allowed level (even with very limited public stock interventions), simply because the subsidy provided by public stocks is overestimated by WTO rules. This result challenges the widespread idea that almost all countries comply with WTO rules on public stocks**.**
We also test the effect of individually correcting biases B1, B2 and B3. It appears that doing so would *not* eliminate the bias on country compliance. One implication of this is that expressing the fixed external reference price (FERP) in US dollars, correcting it with the country inflation rate or replacing it by the average unit value of imports or exports over the last five years (as proposed by some experts and WTO Members) would not be enough to remove the bias on country compliance. It is therefore necessary to correct all three biases, which can be achieved in a rather simple manner, as shown at the end of the paper.

Keywords: World Trade Organization, Doha Round, Bali Agreement, Public stock, Subsidy, Domestic support

Identifier, estimer et corriger les biais des règles de l'OMC sur les stocks publics. Une proposition pour l'agenda post-Bali sur la sécurité alimentaire

Résumé
Dans cet article, nous analysons les règles de l'OMC qui définissent comment estimer la subvention procurée par les stocks publics aux producteurs agricoles. Nous identifions trois biais dans ces règles :
- le biais B1, qui résulte du fait d'utiliser comme prix extérieur de référence la valeur unitaire des importations ou des exportations au cours d'une période fixe passée, au lieu d'utiliser le coût de revient actuel des importations ou des exportations.

- le biais B2, qui résulte du fait d'utiliser le prix d'achat du stock public (au lieu du prix en vigueur sur le marché domestique) pour estimer la subvention reçue par les agriculteurs qui vendent leur production sur le marché domestique.
- le biais B3, qui résulte du fait d'utiliser la production nationale au lieu de la part commercialisée de cette production (ignorant par la même l'autoconsommation des producteurs).

L'effet de ces trois biais sur la subvention estimée diffère selon les pays mais, en moyenne, les règles de l'OMC conduisent à surestimer la subvention d'un facteur 2 à plus de 300, selon les modalités d'intervention des stocks publics et les caractéristiques des pays. Cela signifie que, dans les scénarios les plus favorables, la subvention estimée représente en moyenne le double de la subvention réelle.

L'effet de ces biais sur la conformité des pays avec leurs engagements à l'OMC se révèle être très important : beaucoup de pays ont une subvention estimée au-dessus du plafond autorisé (même avec des interventions de faible ampleur), simplement parce que la subvention est surestimée par les règles de l'OMC. Ceci remet en cause l'idée très répandue selon laquelle presque tous les pays seraient en règles vis-à-vis de leurs engagements sur les stocks publics et le soutien interne.

Nous avons également testé les effets d'une correction partielle des biais B1, B2 et B3. Il s'avère que cette correction partielle ne permet pas d'éliminer le biais sur la conformité des pays avec leurs engagements à l'OMC. Ceci implique notamment qu'exprimer le prix fixe extérieur de référence (FERP) en dollar US, que le corriger par le taux d'inflation du pays ou que le remplacer par la moyenne de la valeur unitaire des importations ou des exportations au cours des cinq années précédentes (comme proposé par différents experts et pays Membres) ne serait pas suffisant pour corriger le bais sur la conformité des pays avec leurs engagements.

Il est donc nécessaire de corriger les trois biais, ce qui peut être fait d'une manière assez simple, comme nous le montrons à la fin de l'article.

Mots-clés : Organisation Mondiale du Commerce, Cycle de Doha, Accord de Bali, Stock public, Subvention, Soutien interne

JEL : Q18, Q11, F1

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Introduction

WTO rules on public stocks (PS) are part of the Agreement on Agriculture (AoA) that was negotiated during the Uruguay Round of the General Agreement on Tariffs and Trade and entered into force with the establishment of the WTO on 1 January 1995. India and the G33 countries proposed modifications to these rules (Bellman et al., 2013)[1], which were consequently debated during the Bali Ministerial Conference in December 2013. However, the Bali conference failed to produce an agreement on this issue: Members simply agreed on a peace clause exempting the already existing public stockholding programmes from legal challenges until a "permanent solution" is found (WTO, 2013; Diaz-Bonilla, 2014). The need to find a permanent solution to the issue of public stockholding for food security purposes was reaffirmed in December 2015 during the Nairobi Ministerial Conference (WTO, 2015a).

The debates on this matter between WTO Members can be organised around two key questions[2]:
Q1. Should the rules on how to estimate the subsidy provided to farmers by public stocks be modified?
Q2. Should the maximum allowed subsidy level be increased, at least for specific countries, commodities and/or situations (safeguard clauses)?

In this article, we analyse the first question, relating to the metrics (the right way to estimate the subsidy provided by PS). We show that current WTO rules generally result in the subsidy provided by public stocks being significantly overestimated, and that this has a huge effect on countries' compliance with their WTO domestic support commitments.
We will successively present i) WTO disciplines on public stocks, ii) the biases in these rules, iii) the magnitude of these biases, iv) their effect on the estimated subsidy, and v) their effect on country compliance. We will conclude by proposing new rules to estimate the subsidy provided by public stocks as accurately as possible.

1. WTO disciplines on public stocks

1.1. General principles

The AoA established disciplines on "market access" (part III), "domestic support" (part IV) and "export subsidies" (part V) (WTO, 1994). Domestic support measures are classified into two broad categories:

- measures that are bounded (Amber Box)
- measures that are exempt from any disciplines, because i) they are considered to have "no or at most minimal" distorting effects on trade or production (Annex 2, also referred to as the "Green Box")[3], ii) they are accompanied by production-limiting programmes (Article 6.5 or "Blue Box"), and iii) they concern "investment subsidies which are generally available to agriculture in developing country Members and agricultural input subsidies generally available to low-income or resource-poor producers in developing country Members" (Article 6.2, sometimes called the "Development Box").

Public stocks (PS) are generally classified in the Amber box, but under specific conditions they may be classified in the Green box. These conditions (defined in Annex 2 of the AoA, more specifically in Paragraphs 3 and 4) are as follows: i) PS should be focused on food security, ii) their management should be transparent, iii) food purchases by the government should be made "at current market prices", and iv) sales from PS should be made "at no less than the current domestic market price", except if these sales are targeted "to sections of the population in need", the "eligibility to receive the food aid [being] subject to clearly-defined criteria related to nutritional objectives".

The practical implication of these conditions is that only some types of PS can be classified in the Green box. Public stocks are usually grouped according to three types, depending on their objective (see for instance Deuss, 2014): i) *emergency reserves*, which provide free or subsidised food to specific subsets of the population in periods of crisis, ii) s*ocial safety net PS*, which provide free or subsidised food to specific subsets of the population in normal times (with the goal of addressing chronic malnutrition), and iii) *buffer stocks*, the purpose of which is to stabilise prices (keeping them above a floor and/or below a ceiling). Buffer stocks are of course excluded from the Green box because they do not meet the third and/or fourth condition (by definition, they purchase and/or sell at administered prices). Social safety net PS are also often excluded from the Green box because purchasing at an administered price is often the only practical way of buying the large quantities required to supply large food distribution systems. It is only for emergency reserves that buying at the market price is an option (this is, for instance, the way the *Stock National de Sécurité* in each Sahel countries procures grain on its domestic market). When a PS is classified in the Amber box, the subsidy provided by this PS is bounded.

1.2. Domestic support ceilings

When not classified in the Green box, the subsidy provided by PS should be accounted for in the Aggregate Measurement of Support (AMS) of the product in question. An AMS is calculated for each agricultural product that receives some kind of domestic support. A "non-product-specific AMS" is also calculated for support that may benefit several products (such as some kind of insurance subsidy). If a product-specific AMS or non-product-specific AMS is above a certain threshold called *de minimis*, it is included in the calculation of the Total AMS, which is bounded by the WTO. The *de minimis* is defined as a percentage of the value of national production of the product in question (for the product-specific AMS) and of total agricultural production (for the non-product-specific AMS). This percentage amounts to 5% for developed countries, 10% for developing countries and 8.5% for China.

The country Total AMS ceiling is determined by the level of the country Total AMS during a reference period called the "base period" in the AoA. The base period depends on the year in which a country became a Member of the WTO: for countries that have been Members since the beginning of the WTO (because they were already Members of the GATT), the base period is 1986-88. Of the 133 WTO Members subject to domestic support disciplines (all WTO Members except the 28 EU Members, because domestic support disciplines are calculated and notified at the EU level), 101 have a base period Total AMS equal to zero. For these countries, the Total AMS ceiling is equal to zero. For the remaining 32 countries, the Total AMS ceiling is their base period Total AMS reduced by 20 % (for

developed country Members) or by 13 % (for developing country Members)[4]. Table 1 in appendix 1 shows country base period, *de minimis* and Total AMS ceiling.

What are the implications of these rules for the maximum subsidy level countries are allowed to apply to a specific commodity C? For countries with a Total AMS ceiling below their *de minimis* for C, the maximum allowed subsidy level for C is this *de minimis*. For countries with a Total AMS ceiling above the *de minimis* for C, the maximum allowed subsidy level for C depends on the way the country Total AMS ceiling is allocated between C, the other commodities and the non-product-specific AMS: if 0% of the Total AMS ceiling is allocated to C, the maximum allowed subsidy level is the *de minimis*; if it is 100%, the maximum allowed subsidy level is the Total AMS ceiling (if, for instance, Canada decides to use all of its Total AMS ceiling to support wheat production, it will be able to provide a subsidy equal to 64.98% of the value of its wheat production, which is well above its *de minimis* level of 5%, see table 1, appendix 1). More generally, if p is the percentage of the country Total AMS ceiling allocated to C, the compliance rule is given by:

$$AMS(C) \leq \text{Max}\ [\textit{de minimis}\ (C);\ p\ \text{Total AMS ceiling}] \quad (1)$$

Note that AMS(C), the AMS for C, encompasses not only the subsidy provided by PS but all types of Amber box domestic supports provided to C. However, in practice, the subsidy provided by PS accounts for the greater part of AMS(C). The key reason for this is that the main types of domestic support used by countries fall within the Green box: this is particularly the case for decoupled direct payments provided by developed countries (which are assumed to be non-distortive) and input subsidies or investment subsidies provided by developing countries (which are exempt from domestic support disciplines in order "to encourage agricultural and rural development", see WTO, 1994, Article 6.2).

1.3. Rules on how the subsidy provided by public stocks should be estimated

The AoA (especially Annex 3) specifies how the subsidy provided by PS to the producers of a specific commodity should be calculated (WTO, 1994). This subsidy (S_{WTO}) is equal to the product of i) the difference between the PS procurement price (P_{PROC}) and a fixed external reference price (FERP), and ii) the quantity of production eligible ($Q_{ELIGIBLE}$):

$$S_{WTO} = (P_{PROC} - FERP)\ Q_{ELIGIBLE} \quad (2)$$

The fixed external reference price (FERP) "shall generally be the average f.o.b. unit value for the basic agricultural product concerned in a net exporting country and the average c.i.f. unit value for the basic agricultural product concerned in a net importing country in the base period" (Annex 3, Article 9), the base period being 1986-88 for the countries that joined the WTO at the outset. The AoA also specifies that the quantity eligible ($Q_{ELIGIBLE}$) is "the quantity of production eligible to receive the applied administered price" (Annex 3, Article 8).

However, several debates emerged among experts and WTO Members regarding the way to interpret these definitions of FERP and $Q_{ELIGIBLE}$. The three main debates are the following:

DEBATE 1. *Should the FERP be expressed in US dollars (USD) or in local currency units (LCU)?* According to some interpretations, the FERP should be expressed in LCU, whereas for other experts, countries should be able to choose whether to express the FERP in LCU or in USD. A third interpretation is that countries should use the currency they used in their first notification, when they notified their AMS for the base period (Hoda and Gulati, 2013). Nothing in the AoA helps to choose between these competing interpretations: the AoA does not specify the currency that should be used to express the FERP and is rather ambiguous regarding the role of the methodology used in country notifications for the base period[5].

DEBATE 2. *Should the FERP be considered as a current price or a real price?* If the FERP is considered as a real price, the price of the base period should be corrected using the country inflation rate since the base period. However, the AoA does not support this interpretation because the case for inflation is dealt with in another article of the AoA (Article 18.4), which mentions that "in the review process Members shall give due consideration to the influence of excessive rates of inflation on the ability of any Member to abide by its domestic support commitments". Although some experts interpreted this as meaning it may give countries the right to update the base period FERP with the domestic inflation rate (Hoda and Gulati, 2013), the dominant view is that this is not the case: Article 18.4 only mentions "*excessive* rates of inflation" and deals more with considerations to be taken into account when assessing the situation of countries that have been unable to comply with their commitments than with calculating the subsidy itself (WTO, 2014). It seems therefore that the FERP should be considered as a current price.

DEBATE 3. *What quantity should be used for $Q_{ELIGIBLE}$?* Some countries notify total national production, while others notify only the quantity actually procured by the PS. Another interpretation is that the relevant quantity is the share of production that is marketed (i.e. that is not self-consumed by farmers). This interpretation (proposed, for instance, by Hoda and Gulati, 2007) is supported by the idea that if public stock purchases affect the domestic market price, only marketed quantities will benefit from this (not the share of production that is self-consumed by farmers). Another view is that if the PS authorities gave prior notice of the quantity they wanted to buy, then $Q_{ELIGIBLE}$ would be this quantity. We therefore have four different interpretations of $Q_{ELIGIBLE}$ (classified here from the smallest to the largest quantity): the quantity actually procured by the PS, the quantity to be purchased announced by the PS authorities, the marketed share of national production, and total national production[6].

These different ways of interpreting the FERP and $Q_{ELIGIBLE}$ may significantly affect the estimated subsidy and countries' compliance with their WTO commitments, as shown by Brink (2014a) for the case of rice, wheat, cotton and sugarcane in India, and by Konandreas and Mermigkas (2014) for specific country-commodity pairs.

Does the jurisprudence shed any light on these debates? To our knowledge, the Korea beef case is the only decision on domestic support made by the WTO Appellate Body[7]: this case is therefore the only one that provides some insights into how to interpret WTO rules on public stocks. The complainants were Australia and the United States. The first decision was made by a three-person panel agreed by all the parties (WTO, 2000a). Korea appealed this decision and the WTO Appellate Body made the final decision (WTO, 2000b). As far as WTO rules on public stocks are concerned, the main discussions centered on the correct way to interpret $Q_{ELIGIBLE}$. Korea argued that $Q_{ELIGIBLE}$ should

be the quantity actually procured because this is the quantity for which there is *actually* money available to pay the PS procurement price (WTO, 2000a, §371). The Panel made it very clear that this interpretation was wrong because what matters is not the actual amount of budgetary outlays (as confirmed by the last sentence of paragraph 8, Annex 3 of the AoA), but the fact that "it is marketable production as a whole which benefits from this type of [price] support" (WTO, 2000a, §832). The Appellate Body confirmed that "production eligible refers to production that is 'fit or entitled' to be purchased rather than production that was actually purchased" (WTO, 2000b, §120). It is worth noting that it did not make any mention of the concept of "marketable production" used by the Panel. Finally, the Appellate Body clarified that if the quantity to be procured is announced in advance, this quantity should be considered as the eligible production (WTO, 2000b, §121).

It thus appears that DEBATE 2 does not really reflect any ambiguity in the AoA, as a careful reading of Article 18.4 seems to imply that the FERP is a current price (which should *not* therefore be corrected by inflation). It also appears that DEBATE 3 has been clarified by the jurisprudence: according to the WTO Appellate Body decision for the Korea beef case, $Q_{ELIGIBLE}$ should be the total national production, unless the quantity to be procured is announced in advance (in this case, $Q_{ELIGIBLE}$ is this quantity). Therefore, the main remaining ambiguity relates to the currency countries should use to express the FERP (DEBATE 1). This is why in the remainder of this document we will always consider two interpretations of the rules, one with the FERP expressed in local currency units and one with the FERP expressed in US dollars.

2. Identifying the biases in WTO rules

2.1. Estimating the real subsidy provided by public stocks

Analysing the subsidy provided to farmers by public stocks (PS) means comparing the income received by farmers when these PS intervene on the market (purchases, sales and free distributions) with the income they would have received without these interventions. An obvious effect is that PS purchases provide a direct subsidy to the farmers that supply the PS, providing that the PS procurement price (P_{PROC}) is higher than the price these farmers would have obtained without PS purchases. In addition, public stock procurement may result in an increase in the domestic price and thereby provide a subsidy to the farmers selling their production on the domestic market. Therefore, in order to estimate the subsidy amounts provided by public stocks, it is necessary to take into account the (direct) subsidy S1 received by the farmers who supply the public stock and the (indirect) subsidy S2 received by the farmers who sell some of their production on the domestic market.

P_D' is the price that would have prevailed on the domestic market without PS intervention. If we assume that the quantity sold to the public stocks (Q_{PROC}) would have been sold on the domestic market if the public stocks had not purchased, then S1 is given by:

$$S1 = (P_{PROC} - P'_D)\, Q_{PROC} \qquad (3)$$

If $Q_{MARKETED}$ is the total quantity sold by farmers (either on the domestic market or to the PS) and P_D is the price prevailing on the domestic market (with PS interventions), S2 is given by:

$$S2 = (P_D - P'_D)\,(Q_{MARKETED} - Q_{PROC}) \qquad (4)$$

We therefore obtain:

$$S = (P_{PROC} - P'_D)\, Q_{PROC} + (P_D - P'_D)\, (Q_{MARKETED} - Q_{PROC}) \quad (5)$$

In this formula, the value of P_D' is unknown: P_D' cannot be observed because it is not a real price but a counterfactual price (the price that would have prevailed on the domestic market in the counterfactual situation without PS interventions). We must therefore replace P_D' by a proxy. But which proxy? As PS intervention may affect domestic prices, the only option is to use an external reference price (ERP). But which ERP? For importing countries, the domestic price is usually determined by the price cost of imports, or "import parity price" (P_M). Similarly, for exporting countries, the domestic price is usually determined by the price cost of exports, or "export parity price" (P_X). It appears, therefore, that the best proxy for the domestic price without PS intervention (P'_D) is the parity price PP (P_M for net importing countries and P_X for net exporting countries). By replacing P'_D with PP in formula 5, we get:

$$S = (P_{PROC} - PP)\, Q_{PROC} + (P_D - PP)\, (Q_{MARKETED} - Q_{PROC}) \quad (6)$$

The next step is to compare the unbiased estimation of the subsidy provided by formula 6 with the subsidy calculated according to WTO rules (formula 2). This will enable us to identify the biases in WTO rules on PS.

2.2. Identifying the biases in WTO rules: B1, B2 and B3

As we have seen in section 1c, the most orthodox view (confirmed by the jurisprudence) is that $Q_{ELIGIBLE}$ means "national production" (becoming $Q_{PRODUCED}$). Formula 2 then becomes:

$$S_{WTO} = (P_{PROC} - FERP)\, Q_{PRODUCED} \quad (7)$$

This formula implicitly assumes that farmers who do not supply the PS receive the same unitary subsidy as farmers who do. To make this clearer, it is better to separate these two categories of subsidies. The formula then becomes:

$$S_{WTO} = (P_{PROC} - FERP)\, Q_{PROC} + (P_{PROC} - FERP)\, (Q_{PRODUCED} - Q_{PROC}) \quad (8)$$

The subsidy calculated according to WTO rules (S_{WTO}) can then easily be compared with the unbiased estimation of the subsidy (S) calculated with formula 6. The comparison of these two formulas shows three biases in WTO rules:

Bias B1, resulting from the use of a fixed past unit value of imports or exports as the external reference price (FERP), instead of the current price cost of imports or exports (also called the parity price, PP).

Bias B2, resulting from the use of the procurement price P_{PROC} instead of the price prevailing on the domestic market P_D to estimate the price support received by farmers selling their production on the domestic market.

Bias B3, resulting from the use of total national production $Q_{PRODUCED}$ instead of the marketed share of national production ($Q_{MARKETED}$) to estimate the subsidy received by farmers (thereby ignoring farmers' self-consumption).

We define the following variables to measure these biases:
B1 = FERP / PP
B2 = P_{PROC} / P_D
B3 = $Q_{PRODUCED}$ / $Q_{MARKETED}$

The subsidy calculated according to WTO rules (S_{WTO}) can then be expressed using B1, B2 and B3:

$$S_{WTO} = (P_{PROC} - PP\ B1)\ Q_{PROC} + (P_D\ B2 - PP\ B1)\ (Q_{MARKETED}\ B3 - Q_{PROC}) \quad (9)$$

The next step is to estimate the magnitude of biases B1, B2 and B3.

3. Estimating the magnitude of the biases in WTO rules

3.1. Estimating the magnitude of bias B1

B1 (equal to FERP / PP) expresses the bias produced by using a fixed external reference price FERP instead of the current parity price PP as a reference price. As defined by the WTO Agreement on Agriculture (WTO, 1994), the FERP is the average unit value of exports (for net exporting countries) or imports (for net importing countries) of the commodity concerned during the country base period (1986-88 for most countries, see appendix 1). The current parity price PP expresses the current price cost of exports (for net exporting countries) or imports (for net importing countries). In order to be comparable with the price received by farmers when they sell to the PS (P_{PROC}) or on the domestic market (P_D), PP should be expressed as a "producer price equivalent". This means that, for net exporting countries, the (transfer) cost of moving the commodity from the producing areas to the border should be included in the estimation of PP as well as the (transaction) cost of transferring property rights from farmers to exporters. Therefore, the price cost of exports (or "export parity price" P_X) is determined by the current unit value of exports (the price received by exporters for a product delivered to the border of the country) converted into local currency plus export subsidies minus the transfer and transaction cost (TTC) from farmers on rural markets to exporters at the border. Similarly, the price cost of imports (or "import parity price" P_M) is equal to the current unit value of imports converted into local currency plus import taxes plus the TTC[8].

Therefore, if UVM_{BP} is the unit value of imports during the base period, $UVM_{CURRENT}$ the current unit value of imports, ER_{BP} the exchange rate with the US dollar during the base period, $ER_{CURRENT}$ the current exchange rate with the US dollar, t_M the import tax rate and ttc the TTC expressed as a percentage of the import unit value plus import taxes, *for net importing countries*, B1 can be expressed by:

$$B1 = (UVM_{BP} / UVM_{CURRENT})\ (ER_{BP} / ER_{CURRENT})\ (1 / 1 + t_M)\ (1 / 1 + ttc) \quad (10)$$

Similarly, if s_X is the export subsidy rate, for *net exporting countries*, B1 is given by:

$$B1 = (UVX_{BP} / UVX_{CURRENT}) (ER_{BP} / ER_{CURRENT}) (1 / 1 + s_X) (1 / 1 - ttc) \quad (11)$$

Formulas 10 and 11 show that bias B1 can be expressed as the product of four sub-biases:
B1a = $UV_{BP} / UV_{CURRENT}$, resulting from the use of a past unit value of imports or exports (the one from the base period) instead of the current unit value

B1b = $ER_{BP} / ER_{CURRENT}$, resulting from the use of a past exchange rate (the one from the base period) instead of the current exchange rate

B1c, resulting from not including taxes or subsidies on imports or exports (B1c = $1 / 1 + t_M$ for importing countries and B1c = $1 / 1 + s_X$ for exporting countries)

B1d, resulting from not including the transport and transaction cost between importers or exporters at the border and farmers on rural markets (for importing countries, B1d = 1 / 1 + ttc and for exporting countries B1d = 1 / 1 – ttc).

As we have seen before, whether countries should express the FERP in local currency units (LCU) or in US dollars (USD) is unclear (see section 1c). If the FERP is expressed in USD, $ER_{BP} = ER_{CURRENT} = 1$ and bias B1b disappears (B1b = 1). In the following sections, we will use both possible definitions of B1: with bias B1b (expressing the fact that the FERP is expressed in LCU) and without bias B1b (expressing the fact that the FERP is expressed in USD). We thus obtain:

$$B1 = B1a\ B1b\ B1c\ B1d \text{ (if the FERP is expressed in LCU)} \quad (12)$$

$$B1 = B1a\ B1c\ B1d \text{ (if the FERP is expressed in USD)} \quad (13)$$

In order to estimate B1, we estimated B1a, B1b, B1c and B1d separately. We conducted this analysis for the case of wheat. Our analysis covers 132 of the 133 WTO Members that have domestic support commitments[9] (Lichtenstein was not included because this country is not in the FAOSTAT database, which is the one we used for data on country import and export unit values). We conducted the analysis for 2011 (taking 2011 as the year representing the current period): the most recent year available in the FAOSTAT database is 2012, but as the most recent year available in the CEPII database on import taxes (needed to estimate B1c) is 2011, that is the year we chose. We used FAOSTAT data for country import and export unit values (to estimate B1a) and World Bank data for exchanges rates[10] (to estimate B1b). To estimate B1c, we used WTO data on export subsidies[11] and CEPII data on applied import taxes[12]. Estimating B1d is more difficult because of the lack of systematic data on transfer and transaction costs. We therefore used the ratio between the wholesale price at the border and the average producer price as a proxy for ttc. More specifically, in order to smooth the potential effect of price fluctuations, we took the Olympic average of this ratio over the last five years as a proxy for ttc. The wholesale price at the border has been approximated by the unit value of exports (for net exporting countries) and by the unit value of imports plus import taxes (for net importing countries)[13]. For producer prices, we used the data provided by FAOSTAT[14].
We have been able to estimate B1 for 118 countries (out of 132) with the definition of B1 where the FERP is expressed in US dollars, and for 114 countries with the definition of B1 where the FERP is expressed in local currency units: 14 countries did not import or export in 2011 or during their base period (preventing us from estimating their B1a) and data on exchange rates are missing for four countries (preventing us from estimating their B1b). The estimated values of B1a, B1b, B1c and B1d

(by country) are presented in appendix 2, as well as the resulting estimation of B1 (for the two possible definitions of B1: with and without B1b).

B1 varies from country to country, but on average its value is 0.47 (with a standard deviation of 0.21) with the definition of B1 that does not include the exchange rate bias, and 0.29 (with a standard deviation of 0.27) with the definition of B1 that does include the exchange rate bias. The average value of B1 is lower in the second case because, for most countries, the exchange rate with the US dollar has decreased over time (B1b < 1). This means that, on average, the external reference price (ERP) specified by WTO rules only accounts for 47% or 29% of the value of the relevant ERP (the current price cost of imports or exports). This implies that if the current price cost of imports or exports is 100, and if the PS is purchasing at 120, the real unitary subsidy is 20, but the unitary subsidy calculated according to WTO rules is on average 73 (120-47) or 91 (120-29), depending on the definition used for B1. Therefore, when the real price support provided by public stocks is 20%, bias B1 leads to the subsidy provided by public stocks being overestimated by a factor of 3.65 or 4.55 on average.

Table 1 below shows that when the exchange rate bias B1b is not included in B1, the average value for B1 (0.47) mainly reflects the evolution of international wheat prices between 1986-1988 (which is the base period for most countries) and 2011. Table 1 also suggests that for maize and rice, B1 is probably of the same order of magnitude as for wheat (or even lower)[15].

Table 1. 1986-1988 grain prices compared to current prices

	1986	1987	1988	Average 1986-1988 (1)	2011	2012	2013	Average 2011-2013 (2)	(1) / (2)
Maize, US	88	76	107	90	292	298	259	283	0.32
Wheat, US, HRW	115	113	145	124	316	313	312	314	0.40
Wheat, US, SRW	118	112	141	124	286	295	277	286	0.43
Rice, Thai, A1.Special	104	154	220	159	459	525	474	486	0.33
Rice, Thailand, 25%	104	191	258	184	506	544	473	508	0.36
Rice, Thailand, 5%	186	215	277	226	543	563	506	537	0.42

Unit: USD/MT
Source: Global Economic Monitor (GEM) Commodities. US Department of Agriculture; World Bank.

3.2. Estimating the magnitude of bias B2

Bias B2 results from the use of the public stock procurement price P_{PROC} instead of the price prevailing on the domestic market P_D to estimate the price obtained by farmers selling their production on the domestic market ($B2 = P_{PROC} / P_D$).

B2 therefore depends on the effect of public stock interventions on the domestic price. This effect depends on the modalities of PS interventions, especially the quantity procured (Q_{PROC}) and the quantity released ($Q_{RELEASED}$) by the PS on the domestic market. The quantity released (in the form of sales and/or free distributions) may be lower or higher than Q_{PROC}, depending on the objectives of

the PS: if the objective is to support the domestic price, part of the quantity stored will be exported and will usually give $Q_{PROC} > Q_{RELEASED}$; if the objective is to supply safety nets that distribute food to poor households, this may give $Q_{PROC} = Q_{RELEASED}$ (if the system is 100% supplied by domestic production) or $Q_{PROC} < Q_{RELEASED}$ (if the system is partly supplied by imports); if the objective is to supply emergency aid in periods of crisis, Q_{PROC} may be much higher than $Q_{RELEASED}$ in some years and much lower in others. Consequently, the net effect of PS interventions may be the removal of quantities from the domestic market (when $Q_{PROC} > Q_{RELEASED}$) or the injection of quantities into the domestic market (when $Q_{PROC} < Q_{RELEASED}$). As a result, PS can generate upward or downward pressure on the domestic price.
The effect of public stock interventions on the domestic price also depends on country characteristics, especially the way in which market players react to public stock interventions by adjusting their stocks, their imports and/or their exports. For instance, when the public stock procures grain, market players' incentive to store is reduced: the current price increases and the price expected for the future decreases (as players expect that the public stock will release significant quantities in the future). Market players are therefore likely to reduce their purchases or to increase their sales: part of the quantity removed from the market by PS procurement (Q_{PROC}) is offset by a reduction in private storage. Similarly, the quantity removed from the market by PS procurement may be (partly or fully) offset by an increase in country imports or a decrease in exports.

As a result, the assumption that the procurement price P_{PROC} makes the domestic price P_D (which is the implicit assumption behind WTO rules) is not always satisfied: it may also be that PS procurement pushes up the domestic price without allowing it to reach P_{PROC}, or that PS procurement does not affect the domestic price because the quantity procured is low or is offset by an adjustment in imports or exports, for instance. It may even be that the domestic price falls because of PS interventions (because the PS release exceeds the PS procurement).

The magnitude of B2 and of its effect on the estimation of the subsidy provided by PS can be illustrated by the following example. Let us assume that the PS purchases 10% of national production, the remaining 90% being sold on the domestic market. If the procurement price is 30% higher than the parity price PP, the subsidy received by the farmers who supply the PS is 30%. According to WTO rules, all farmers receive this amount of subsidy: the average price support is therefore considered to be 30%. If the domestic price actually increases by 30%, B2 = 1 and the (average) price increase is actually 30%. However, if the domestic price only increases by 15%, B2 = 1.13 and the average price increase is only 16.5% (0.1 x 30% + 0.9 x 15%), meaning that B2 results in the subsidy being overestimated by 81%. If the domestic price does not increase, B2 = 1.3 and the average price increase is only 3% (meaning that B2 results in the subsidy being overestimated by a factor of 10). If the domestic price decreases by 10%, B2 = 1.44 and the average price *decreases* by 6% (0.1 x 30% - 0.9 x 10%): in this case, WTO rules estimate a 30% subsidy when in reality PS interventions result on average in a 6% tax on farmers.

This example shows that bias B2 may lead to the subsidy provided by PS being significantly overestimated (including in some cases considering that there is a subsidy, when in reality there is a tax).

3.3. Estimating the magnitude of bias B3

Bias B3 results from the assumption that all national production benefits from the price support provided by PS. The implicit assumption behind WTO rules is that farmers sell all their production (no self-consumption). Obviously, this is often far from the reality in developing countries, especially for grain and other staple food products. No systematic data on the marketed share of production by country and commodity exist. However, we have been able to gather data for specific staples in specific countries, enabling us to estimate B3 for many commodity-country pairs. If δ is the percentage of national production marketed by farmers ($\delta = Q_{MARKETED} / Q_{PRODUCED}$), then B3 = 1 / δ. Our estimations of B3 are presented in table 2 below.

This table shows that bias B3 varies widely depending on the country and commodity concerned. For rice in India, for example, where it is estimated that 81% of production is marketed, B3 = 1.23. But in the case of maize in Eastern and Southern African countries (where only 14% to 22% of production is marketed), B3 ranges from 4.5 to 7.

Table 2. Estimated values of B3 (for selected staples and countries)

	Maize	Millet & sorghum	Rice	Wheat	Cassava	Yam
Western Africa + Chad and Cameroon						
Benin (2011)	1.54	9.58	1.11	1.03	3.24	2.07
Burkina Faso (2003)	2.03	3.44	1.12	1.02		
Cameroon (2007)	2.06	4.34	1.08	1.06	1.74	1.94
Chad (2011)	1.56	4.40	1.45	1.15	1.42	1.88
Côte d'Ivoire (2008)	2.50	1.45	1.29	1.01	1.69	3.16
Ghana (2006)	1.38	3.19	1.01	1.00	1.81	1.88
Guinea (2007)	4.59	4.92	1.77	1.04	2.40	1.30
Liberia (2007)	2.98		1.46	1.06	2.33	1.70
Mali (2011 and 2009)	2.12	1.94	1.21	1.03	1.11	1.23
Mauritania (2008)	2.50	3.74	1.02	1.00	1.00	
Niger (2011)	1.09	1.89	1.12	1.05	1.05	1.03
Nigeria (2003)	1.63	3.73	1.08	1.04	1.95	1.65
Senegal (2010)	1.46	1.62	1.06	1.00	1.04	1.07
Sierra Leone (2003)	2.34	1.74	1.57	1.00	1.88	2.85
Togo (2011)	2.37	5.70	1.17	1.00	1.57	1.82
Eastern and Southern Africa						
Kenya (2007)	4.55					
Malawi (2007)	4.76					
Mozambique (2005)	6.25					
Zambia (2008)	7.14					
Asia						
India			1.23	1.37		

Sources: MALVILAO project for West African countries + Chad and Cameroon (Bricas et al., 2016); Jayne et al. (2010) for Eastern and Southern African countries, and Blink (2014a) for India.
For Mali, data are from 2011 for grain and from 2009 for roots and tubers.

What are the implications of these B3 values when estimating the subsidy provided by PS? Let us take an example. We consider a country where the PS buys 10% of national production, the remaining 90% being either sold on the domestic market or self-consumed by farmers. We assume

that PS procurement generates an increase in the domestic price that becomes equal to the procurement price (therefore B2 = 1: all farmers receive the same subsidy). If 80% of the production is marketed (then B3 = 1.25), 10% is sold to the PS, 70% is sold on the domestic market and 20% is self-consumed by farmers. Bias B3 (ignoring self-consumption) results in wrongly allocating a subsidy to the 20% self-consumed by farmers, thereby overestimating the subsidy by 25% (or by a factor of 1.25). If only 20% of production is marketed (then B3 = 5), 10% is sold to the PS, 10% is sold on the domestic market and 80% is self-consumed by farmers. Bias B3 results in wrongly allocating a subsidy to the 80% self-consumed by farmers, thereby overestimating the subsidy by a factor of 5.

4. Estimating the effect of the biases on the estimated subsidy

4.1. Methodology

Estimating the bias on the subsidy means comparing the value of the unbiased estimation of the subsidy (S, estimated using formula 6) and the value of the subsidy calculated according to WTO rules (S_{WTO}, estimated using formula 7).

As shown by formula 6, *the unbiased estimation of the subsidy (S)* depends on the modalities of PS intervention: the procurement price P_{PROC}, the procured quantity Q_{PROC} and implicitly $Q_{RELEASED}$ because the quantity released by the PS affects the domestic price P_D). S also depends on country characteristics, more specifically the marketed share of production and the factors that determine the effect of given PS interventions on the domestic price (these factors are mainly due to the ability of traders to smooth the effect of PS interventions by adjusting their stocks, their imports and/or theirs exports, see section 3b).

In order to estimate the subsidy S, we must therefore build scenarios for PS interventions and country characteristics. The main PS intervention and country characteristics can be captured through the following variables:

$\alpha = Q_{PROC} / Q_{PRODUCED}$: quantity procured by the PS expressed as a % of national production

$ß = [P_{PROC} - PP] / PP$: price support provided to the farmers who supply the PS, expressed as a % of the parity price PP

$\gamma = [P_D - PP] / [P_{PROC} - PP]$: increase in the domestic price P_D, expressed as a % of the price support provided to the farmers who supply the PS

$\delta = Q_{MARKETED} / Q_{PRODUCED}$: % of national production that is marketed by farmers

S can thus be expressed as a combination of α, ß, γ, δ, the current parity price PP and the quantity produced $Q_{PRODUCED}$:

$$S = \alpha\, Q_{PRODUCED}\, PP\, ß + (\delta-\alpha)\, Q_{PRODUCED}\, PP\, ß\, \gamma \qquad (14)$$

In order to assess country compliance, S must be compared with the country *de minimis* (see section 1b). As the *de minimis* is a percentage of the production value of the commodity concerned (10% for

developing countries, 5% for developed countries, and 8.5% for China), it is convenient to express S directly as a percentage of the production value (which is equal to $Q_{PRODUCED}$ P_D). We thus obtain:

$$s = ß\,[\alpha + (\delta - \alpha)\,\gamma] / [1 + ß\,\gamma] \quad (15)$$

As shown by formula 7, *the subsidy calculated according to WTO rules (S_{WTO})* depends on the PS procurement price (P_{PROC}), national production ($Q_{PRODUCED}$) and the unit value of imports or exports during a past period called the "base period" (FERP). Using the FERP instead of the current parity price PP is precisely what generates bias B1 (FERP = PP B1). Note that S_{WTO} does not depend on the procured quantity Q_{PROC} and the domestic price P_D (neglecting these two variables is precisely what generates bias B2). Note also that S_{WTO} does not depend on the percentage of production that is marketed (neglecting this variable is precisely what generates bias B3). The subsidy calculated according to WTO rules can therefore be expressed with ß, the quantity produced $Q_{PRODUCED}$, the current parity price PP and B1:

$$S_{WTO} = Q_{PRODUCED}\,[(1 + ß)\,PP - PP\,B1] \quad (16)$$

Expressed as a percentage of the value of national production, the subsidy calculated according to WTO rules is given by:

$$s_{WTO} = [1 + ß - B1] / [1 + ß\,\gamma] \quad (17)$$

The bias in the estimation of the subsidy is defined by $BS = s_{WTO} / s$. We thus obtain:

$$BS = [1 + ß - B1] / ß\,[\alpha + (\delta - \alpha)\,\gamma] \quad (18)$$

In order to capture the whole range of possible modalities for PS interventions, we chose to include a low and a high value for Q_{PROC} and P_{PROC}. We consider that the PS buys 2% or 20% of national production and that the price paid by the PS exceeds the parity price by 10% or 50%. We thus obtain:

α = 2% or 20% (α being the percentage of national production procured by the PS)

ß = 10% or 50% (ß being the price support provided to the farmers who supply the PS)

For the effect of PS interventions on the domestic price P_D, we consider 3 cases: P_D may i) increase by the price support provided to the farmers who supply the PS, ii) increase by half of this price support, or iii) not increase at all. We thus obtain:
γ = 100%, 50% or 0% (γ being the percentage of transmission to the domestic price of the price support provided to the farmers who supply the PS)

Regarding the percentage of national production that is marketed, we consider two values: 100% and 80%. These values may appear highly conservative since this percentage may be much lower for some country-commodity pairs (as is the case for maize in Eastern and Southern African countries, see section 3c). However, these values seem adequate for the case of wheat, which is probably the least self-consumed grain. We thus obtain:

δ = 100% or 80%

With these scenarios for α, ß, γ and δ and the values for B1 estimated in section 3a (for the case of wheat), we can estimate the unbiased subsidy s (using formula 15) and the subsidy s_{WTO} calculated according to WTO rules (using formula 17). The bias in the estimation of the subsidy provided by PS is then given by BS with BS = s_{WTO} / s (formula 18).

4.2. Results

As B1 is different for each country, for a given scenario and a given definition of B1, BS is different for each country. Tables 3 and 4 below present the average and standard deviation of BS for each scenario.

The bias in the estimation of the subsidy (BS) varies widely depending on the scenario concerned. BS ranges from 2.43 to more than 407 (when B1 includes the exchange rate bias) and from 2.06 to more than 314 (when B1 does not include the exchange rate bias).

This means that in the most favourable scenarios, WTO rules overestimate the subsidy provided by PS by a factor of 2 on average (the subsidy calculated according to WTO rules is twice the unbiased estimation of the subsidy). The bias on the subsidy can be much higher: in some scenarios, the subsidy calculated according to WTO rules is more than 300 or 400 times the unbiased estimation of the subsidy.

Table 3: Bias in the estimation of the subsidy provided by PS (case where B1 includes the exchange rate bias)

	Scenarios				**BS (S_{WTO} / s)**	
	α	**ß**	**γ**	**δ**	**Average**	**Standard deviation**
1	2%	10%	0%	80%	407.07	135.26
2	2%	10%	0%	100%	407.07	135.26
3	2%	50%	0%	80%	121.41	27.05
4	2%	50%	0%	100%	121.41	27.05
5	20%	10%	0%	80%	40.71	13.53
6	20%	10%	0%	100%	40.71	13.53
7	20%	10%	50%	80%	16.28	5.41
8	20%	10%	50%	100%	13.57	4.51
9	20%	10%	100%	80%	10.18	3.38
10	20%	10%	100%	100%	8.14	2.71
11	20%	50%	0%	80%	12.14	2.71
12	20%	50%	0%	100%	12.14	2.71
13	20%	50%	50%	80%	4.86	1.08
14	20%	50%	50%	100%	4.05	0.90
15	20%	50%	100%	80%	3.04	0.68
16	20%	50%	100%	100%	2.43	0.54

Table 4: Bias in the estimation of the subsidy provided by PS (case where B1 does not include the exchange rate bias)

Scenarios					BS (S_{WTO} / s)	
	α	ß	γ	δ	Average	Standard deviation
1	2%	10%	0%	80%	314.33	105.27
2	2%	10%	0%	100%	314.33	105.27
3	2%	50%	0%	80%	102.87	21.05
4	2%	50%	0%	100%	102.87	21.05
5	20%	10%	0%	80%	31.43	10.53
6	20%	10%	0%	100%	31.43	10.53
7	20%	10%	50%	80%	12.57	4.21
8	20%	10%	50%	100%	10.48	3.51
9	20%	10%	100%	80%	7.86	2.63
10	20%	10%	100%	100%	6.29	2.11
11	20%	50%	0%	80%	10.29	2.11
12	20%	50%	0%	100%	10.29	2.11
13	20%	50%	50%	80%	4.11	0.84
14	20%	50%	50%	100%	3.43	0.70
15	20%	50%	100%	80%	2.57	0.53
16	20%	50%	100%	100%	2.06	0.42

5. Estimating the effect of the biases on country compliance

5.1. Methodology

In order to estimate the impact of biases B1, B2 and B3 on country compliance, we must compare the compliance estimated i) with the unbiased estimation of the subsidy (s) and ii) with the subsidy calculated according to WTO rules (s_{WTO}). For a specific country, a specific scenario and a specific definition of B1 (including or excluding the exchange rate bias), we have four possible situations (see table 5):

Table 5. Possible effects of biases in WTO rules on compliance: definition of the two types of error

		Compliance when using S (the unbiased estimation of the subsidy)	
		Yes	*No*
Compliance when using S_{WTO} (the subsidy calculated according to WTO rules)	*Yes*	*No effect on compliance*	**[TYPE 2 ERROR]**
	No	**[TYPE 1 ERROR]**	*No effect on compliance*

We therefore have two types of error:

Type 1 error: considering that a country is not complying when it would be complying with an unbiased estimation of the subsidy

Type 2 error: considering that a country is complying when it would not be complying with an unbiased estimation of the subsidy

The compliance of a country with its domestic support commitments is determined by formula 1 presented in section 1b: the country AMS for the commodity concerned should remain below the maximum of two values: i) its *de minimis* for the commodity concerned, and ii) the share of its Total AMS ceiling that is allocated to the commodity concerned:

AMS(C) ≤ Max [*de minimis* (C); p Total AMS ceiling] (1)

In order to assess the compliance of a country that provides an estimated subsidy ES to commodity C (ES is equal to s or s_{WTO}), we therefore define two criteria, a compliance criterion and a "no compliance" criterion:

Compliance criterion: If ES ≤ country *de minimis* (C), there is compliance.

No compliance criterion: If ES > max (country *de minimis* (C); country Total AMS ceiling), there is no compliance

For countries with a Total AMS ceiling below their *de minimis* for C, we will always be able to determine whether there is compliance or no compliance because the estimated subsidy will always be either ≤ or > the *de minimis* for C. For countries with a Total AMS ceiling higher than their *de minimis* for C, things are a bit more complicated because we have three possible situations: i) compliance (when ES ≤ *de minimis*), ii) no compliance (when ES > *de minimis* and ES > Total AMS ceiling), and iii) undetermined (when ES > country *de minimis* and ES ≤ Total AMS ceiling). In the last case, the compliance is undetermined because it depends on the (unknown) percentage of the country Total AMS ceiling that is allocated to C. We can therefore define a lower value and an upper value for the type 1 error and type 2 error (see table 6).

Table 6. Definition of a lower value and an upper value for type 1 error and type 2 error

Type 1 error	
Lower value	Upper value
% of countries for which there is compliance with S and no compliance with S_{WTO}	% of countries for which there is compliance with S and no compliance with S_{WTO} + % of countries for which there is compliance with S and undetermined situation with S_{WTO} + % of countries for which there is undetermined situation with S and no compliance with S_{WTO}

Type 2 error	
Lower value	Upper value S_{WTO}
% of countries for which there is no compliance with S and compliance with S_{WTO}	% of countries for which there is no compliance with S and compliance with S_{WTO} + % of countries for which there is no compliance with S and undetermined situation with S_{WTO} + % of countries for which there is undetermined situation with S and compliance with S_{WTO}

5.2. Results

To estimate the effect of biases B1, B2 and B3 on compliance, we need data on country B1, country *de minimis* and country value of wheat production. The availability of these data enables us to estimate the effect on compliance for 101 countries (when B1 includes the exchange rate bias) and 105 countries (when B1 does not include the exchange rate bias) of the 133 WTO members with domestic support commitments. Of these 101 or 105 countries, 18 have a Total AMS ceiling higher than their *de minimis* for wheat, meaning that situations where compliance is undetermined (see section 5a) can only occur for 18 countries out of 101 or 105. The results are presented in tables 7 and 8 below.

Table 7. Impact of biases in WTO rules on country compliance (case where B1 includes the exchange rate bias)

Scenarios					Compliance rates		Impact on country compliance	
	α	ß	γ	δ	with s	with s_{WTO}	Type 1 error	Type 2 error
1	2%	10%	0%	80%	100%	[3%, 12%]	[88%, 97%]	0%
2	2%	10%	0%	100%	100%	[3%, 12%]	[88%, 97%]	0%
3	2%	50%	0%	80%	100%	[0%, 10%]	[90%, 100%]	0%
4	2%	50%	0%	100%	100%	[0%, 10%]	[90%, 100%]	0%
5	20%	10%	0%	80%	100%	[3%, 12%]	[88%, 97%]	0%
6	20%	10%	0%	100%	100%	[3%, 12%]	[88%, 97%]	0%
7	20%	10%	50%	80%	100%	[3%, 12%]	[88%, 97%]	0%
8	20%	10%	50%	100%	[85%, 95%]	[3%, 12%]	[80%, 86%]	[0%, 2%]
9	20%	10%	100%	80%	[85%, 94%]	[3%, 12%]	[80%, 85%]	[0%, 2%]
10	20%	10%	100%	100%	[84%, 93%]	[3%, 12%]	[79%, 84%]	[0%, 2%]
11	20%	50%	0%	80%	[84%, 93%]	[0%, 10%]	[80%, 86%]	0%
12	20%	50%	0%	100%	[84%, 93%]	[0%, 10%]	[80%, 86%]	0%
13	20%	50%	50%	80%	[0%, 15%]	[0%, 11%]	[0%, 5%]	0%
14	20%	50%	50%	100%	[0%, 13%]	[0%, 11%]	[0%, 3%]	0%
15	20%	50%	100%	80%	[0%, 13%]	[0%, 11%]	[0%, 3%]	0%
16	20%	50%	100%	100%	[0%, 12%]	[0%, 11%]	[0%, 2%]	0%

Table 8. Impact of biases in WTO rules on country compliance (case where B1 does not include the exchange rate bias)

Scenarios					Compliance rates		Impact on country compliance	
	α	ß	γ	δ	with s	with s_{WTO}	Type 1 error	Type 2 error
1	2%	10%	0%	80%	100%	[3%, 12%]	[88%, 97%]	0%
2	2%	10%	0%	100%	100%	[3%, 12%]	[88%, 97%]	0%
3	2%	50%	0%	80%	100%	[0%, 10%]	[90%, 100%]	0%
4	2%	50%	0%	100%	100%	[0%, 10%]	[90%, 100%]	0%
5	20%	10%	0%	80%	100%	[3%, 12%]	[88%, 97%]	0%
6	20%	10%	0%	100%	100%	[3%, 12%]	[88%, 97%]	0%
7	20%	10%	50%	80%	100%	[3%, 12%]	[88%, 97%]	0%
8	20%	10%	50%	100%	[85%, 95%]	[3%, 12%]	[80%, 86%]	[0%, 1%]
9	20%	10%	100%	80%	[85%, 94%]	[3%, 13%]	[79%, 85%]	[0%, 1%]
10	20%	10%	100%	100%	[84%, 93%]	[3%, 13%]	[78%, 84%]	[0%, 1%]
11	20%	50%	0%	80%	[84%, 93%]	[0%, 10%]	[81%, 87%]	0%
12	20%	50%	0%	100%	[84%, 93%]	[0%, 10%]	[81%, 87%]	0%
13	20%	50%	50%	80%	[0%, 15%]	[0%, 10%]	[0%, 6%]	0%
14	20%	50%	50%	100%	[0%, 13%]	[0%, 10%]	[0%, 4%]	0%
15	20%	50%	100%	80%	[0%, 13%]	[0%, 10%]	[0%, 3%]	0%
16	20%	50%	100%	100%	[0%, 12%]	[0%, 10%]	[0%, 2%]	0%

The frequency of type 1 errors is very high, whatever the definition of B1: they affect more than 78% of countries in 12 scenarios out of 16 (the remaining 4 scenarios correspond to situations in which the real subsidy provided by PS is huge, resulting in low compliance rates, even with the unbiased estimation of the subsidy s).

The frequency of type 2 errors is low (it ranges from 0% to 2%), even in the scenarios where the compliance rate with the real subsidy s is low.

These results challenge the widespread idea that almost all countries comply with WTO rules on PS[16]: even in situations with very low PS interventions, many countries may be "in the red" because of the biases in WTO rules. For instance, when the PS purchases only 2% of national production at a price only 10% higher than the current parity price, the real subsidy provided accounts for only 0.2% of the value of national production, which is far below the country *de minimis* (10% of the value of production for developing countries, 5% for developed countries and 8.5% for China). However, more than 88% of the countries are exposed to legal challenge if the subsidy is estimated according to WTO rules (see scenarios 1 and 2 in tables 7 and 8).

Another interesting result is that the effect of biases B1, B2 and B3 on country compliance is almost the same with the two definitions of B1 (the one with the FERP expressed in the local currency unit and the one with the FERP expressed in US dollars, compare tables 7 and 8). Therefore, the idea that allowing countries to express the FERP in US dollars would be sufficient to correct the bias on country compliance is challenged: it is true that this would help to reduce the bias on the estimated subsidy (see tables 3 and 4), but this reduction would not be enough to have a significant effect on country

compliance. This is a pity because it means that clarifying the rules is not enough: in order to remove the bias on country compliance, the rules need to be changed.

Is it necessary to fully correct the three biases B1, B2 and B3? Can we eliminate the effect on country compliance by modifying only some biases or by correcting them only partially? Given the difficulties experienced when attempting to change the rules, it is worth exploring this question.

5.3. The need to correct the three biases

We simulated the effect on country compliance of separately correcting biases B1, B2 and B3. As B1 and B2 proved to be the most important biases, we also simulated the effect of correcting both B1 and B2. The formulas used are presented in appendix 3 and the detailed results are given in appendixes 4, 5, 6, 7 and 8.

We first simulated the effect of partially *correcting B1* by taking the *current* unit value (of exports for net exporting countries and of imports for net importing countries) instead of the unit value of the base period as a reference price. This means correcting B1a and B1b, but not B1c and B1d. The results show that this would eliminate type 1 errors for exporting countries in some scenarios (see tables A and B in appendix 4). However, it would not resolve the problem for either importing countries or exporting countries in the others scenarios. Moreover, it would generate a bias *in favour of* country compliance (type 2 errors) for some exporting countries in some scenarios.

We then simulated the effect of completely correcting B1 (which implies including i) taxes or subsidies on imports or exports, and ii) transfer and transaction costs between rural markets and the border in the calculation of the reference price). However, doing this is not enough, as type 1 errors remained unchanged in some scenarios (see appendix 5). These scenarios are mainly those in which B2 is high, demonstrating the need to correct bias B2.

Correcting B2 alone is also insufficient to eliminate the bias on country compliance: the frequency of type 1 errors remains higher than 76% for 8 scenarios out of 16 (see appendix 6).

Correcting B3 alone would not have a significant effect on country compliance (see appendix 7).

Correcting both B1 and B2 would completely eliminate the biases on country compliance in most scenarios, but not all (see appendix 8). Biases on compliance remain significant in some scenarios, especially those where the real subsidy is close to the compliance threshold of many countries (this is the case for scenario 7). Moreover, it should be remembered that our scenarios for B3 (B3 = 1 or B3 = 1.25) are highly conservative: although these values may be realistic for wheat, B3 may be much higher for other grains (for maize in Eastern and Southern Africa, B3 is higher than 4.5, see section 3c). These remarks show that it is also necessary to correct bias B3.

6. A proposal of new rules for an unbiased estimation of the subsidy provided by public stocks

6.1. A formula to estimate the subsidy

Formula 6 presented in section 2.1 gives an unbiased estimation of the subsidy provided by PS. However, this formula cannot be used by the WTO because it uses the parity price PP, which is only known at the end of the year (PP depends on the average unit value of imports or exports during the year). In order to enable countries to choose the parameters of PS interventions (especially P_{PROC}) with satisfactory knowledge of the subsidy they will generate, countries need prior knowledge of the external reference price (ERP) that will be used in the calculation. The ERP therefore cannot be PP: it should be a predictor variable of PP. This predictor variable (now PP*) should be based on a combination of past unit values of imports or exports. The formula to estimate the subsidy thus becomes:

$$S = (P_{PROC} - PP^*)\, Q_{PROC} + (P_D - PP^*)\, (Q_{MARKETED} - Q_{PROC}) \qquad (19)$$

This formula shows that in order to estimate S, we need to know the value of the procurement price P_{PROC}, the quantity procured Q_{PROC}, the price prevailing on the domestic market P_D, the marketed share of production $Q_{MARKETED}$ and PP*. P_{PROC} and Q_{PROC} are theoretically public data (which should be notified by countries to the WTO). P_D can be observed: it is the average producer price calculated as the annual average of the prices collected on rural markets (the main points of sale for farmers). This data is already used in country notifications to calculate the value of production (and therefore the *de minimis*). $Q_{MARKETED}$ is the share of production sold by farmers. It is usually estimated by applying a ratio δ to the estimated production (δ is estimated with household survey data). The main problem is therefore to estimate PP*.

6.2. Estimating the external reference price PP*

PP* is a predictor variable of the average price cost of imports or exports during year Y. PP* is therefore equal to a predictor variable UV* of the unit value of imports (for net importing countries) and of exports (for net exporting countries) during year Y, corrected by i) the import tax rate t_M (for net importing countries) or the export subsidy rate s_X (for net exporting countries), and ii) the transfer and transaction costs between country rural markets and the international market (TTC). In order to estimate PP*, we therefore need to estimate TTC and UV*.

Let us begin with TTC. *Transfer costs* refer to the costs incurred when moving the product from one locality to another one (transport, handling, illicit taxes on the road, etc.). *Transaction costs* refer to the costs incurred when transferring property rights for the product (the costs of finding potential trade partners, negotiating with them, monitoring quality, reaching agreements, enforcing contracts, etc.). Including the transfer and transaction costs in the estimation of PP* is necessary in order to convert the price received by exporters or paid by importers (for a commodity delivered at the border) into a producer price equivalent (comparable to the price received by farmers on rural markets).

Transfer and transaction costs (TTC) can be estimated indirectly in a simple, reliable and transparent manner using price data. The idea is that these costs are relatively stable over time and reflected by the difference in prices between localities (for transfer costs) and between levels in the supply chain (for transaction costs). A good proxy for TTC is therefore the difference between i) the average producer price on the main rural markets[17], and ii) the average wholesale price at the main entry point of imports or exit point of exports (generally the locality of the port[18]) over a given period of time (for instance the previous 24 or 36 months). If we call this difference ΔP, then PP* is expressed by:

For net exporting countries: $PP^* = UV^* (1 + s_X) + \Delta P$ (20)

For net importing countries: $PP^* = UV^* (1 + t_M) + \Delta P$ (21)

The next step is estimating UV*. UV*is a predictor variable of the average unit value of exports or imports during year Y (UV_Y). It should therefore be based on an average of past unit values of imports or exports. A simple option (already proposed by some experts and WTO Members) is to use the Olympic average of the unit value over the five preceding years (meaning the average calculated by removing the lowest and highest values). We will call it $OAUV_{Y\text{-}5 \text{ to } Y\text{-}1}$. The problem with this option is that most of the time, $OAUV_{Y\text{-}5 \text{ to } Y\text{-}1}$ is lower than UV_Y (*cf*. appendix 9)[19]. Therefore, defining UV* by $OAUV_{Y\text{-}5 \text{ to } Y\text{-}1}$ would lead to a reference price PP* that would (on average) be lower than the parity price PP (resulting in the subsidy provided by public stocks being overestimated).
However, as the errors in predicting UV_Y by $OAUV_{Y\text{-}5 \text{ to } Y\text{-}1}$ are known for the preceding years, it is possible to use the knowledge we have about these errors to improve the predictor variable of UV_Y (UV*). More specifically, if the prediction error is defined by $ERR = UV_Y / OA(UV)_{Y\text{-}5 \text{ to } Y\text{-}1}$, in order to ensure that UV* will on average be equal to UV_Y, UV* should be defined by the product of $OA(UV)_{Y\text{-}5 \text{ to } Y\text{-}1}$ and a correcting factor equal to the average of ERR for a given past period (the five preceding years seems to be a good option).

With this definition of UV*, UV* would be equal to UV_Y on average, but not always: in some years UV* would be below UV_Y (leading to the reference price PP* being underestimated and therefore the subsidy being overestimated), and in other years UV* would be above UV_Y (leading to PP* being overestimated and therefore the subsidy being underestimated). Consequently, if we assume that type 1 errors (estimating that a country does not comply, when in fact its real subsidy is below its maximum allowed level) are worse than type 2 errors (estimating that a country complies, when its real subsidy is above its maximum allowed level), we may wish to reduce the frequency of occurrence of years in which $UV^* < UV_Y$. The logic behind this strategy is the same as the one used to determine whether drivers are complying with the speed limit. As the measurements taken by speed cameras are imperfect (in France the margin of error is around 10%), drivers are given the benefit of the doubt if they are flashed at a speed higher than the speed limit but lower than the speed limit plus the margin of error for speed cameras. This gives us the following formula for UV*:

$UV^* = OA(UV)_{Y\text{-}5 \text{ to } Y\text{-}1}$ (Average [ERR] + Standard Deviation [ERR]) (22)

This definition of UV* is satisfactory because UV* is generally close to UV_Y and because it almost completely avoids the risk of $UV^* < UV_Y$ (which would lead to the subsidy provided by public stocks being overestimated), except for years in which the international price increased substantially (as in 2008) or the country exchange rate with the US dollar fell considerably. This is why **we recommend**

including in WTO rules a safeguard clause exempting countries from WTO disciplines on domestic support when i) their exchange rate has collapsed during the year, or ii) the international price has risen sharply during the year. Indeed, in these situations, part of the estimated subsidy would not be due to PS interventions (but rather to the increase in the parity price).

It thus appears that the subsidy can be estimated quite easily by applying formulas 19 to 22. The greater part of the data required is already notified to the WTO, either to estimate the subsidy or to calculate the *de minimis*. This is the case for the procurement price (P_{PROC}), the quantity procured (Q_{PROC}), national production ($Q_{PRODUCED}$), and the average producer price on rural markets (P_D). Other data can be easily calculated using data already available: UV* is only based on past unit values of imports or exports; the transfer and transaction cost (TTC) can be estimated using data on the wholesale price in the locality of the port and on the producer price on rural markets. The only new data required concerns the marketed share of production, which can be easily estimated using household survey data (for instance from consumption or poverty surveys)[20].

However, for self-sufficient and almost self-sufficient countries, things are more complicated, as we will see.

6.3. The specific case of self-sufficient and almost self-sufficient countries

For self-sufficient countries, estimating the subsidy provided by PS entails large margins of error: the parity price is more difficult to estimate because the country has no data on import or export unit values. Moreover, the parity price is a very poor choice of reference price for the domestic price because this domestic price can be anywhere between the export parity price P_X and the import parity price P_M. As PS interventions do not affect farmers in the rest of the world (at least if the country is structurally self-sufficient), this raises the question of the relevance of maintaining disciplines on PS for this kind of country.

This question also applies to almost self-sufficient countries: these countries can calculate a unit value of imports or exports, but their trade status is likely to be highly unstable, which may result in huge variations in the parity price in case of significant differences between P_X and P_M[21]. Moreover, as the levels of imports and exports are low, the assumption that the domestic price is made by the import or export parity price is highly problematic.

This is why **we propose exempting self-sufficient countries (countries with zero exports and zero imports) and almost self-sufficient countries from WTO disciplines on public stocks. Almost self-sufficient countries are defined as net exporting countries with exports accounting for less than 5% of their production and net importing countries with imports accounting for less than 5% of their consumption.**

Conclusion

We analysed the WTO rules that specify how the subsidy S provided by PS should be estimated. We identified three biases in WTO rules and showed that these biases lead to the subsidy being considerably overestimated (S is overestimated by a factor of 2 to more than 300, depending on the modalities of public stock interventions and country characteristics, see tables 3 and 4).

We also estimated the effect of the biases on country compliance with their domestic support commitments. We considered two types of error:

Type 1 error: considering that a country is not complying when it would be complying with an unbiased estimation of the subsidy;

Type 2 error: considering that a country is complying when it would not be complying with an unbiased estimation of the subsidy.

The effect of biases B1, B2 and B3 on country compliance proved to be huge and asymmetric: type 1 errors affect more than 78% of the countries in 12 scenarios out of 16, whereas the frequency of type 2 errors is low (ranging from 0% to 2%). This means that many countries have an estimated subsidy above their maximum allowed level (even with very limited public stock interventions), simply because the subsidy provided by public stocks is overestimated by WTO rules. This result challenges the widespread idea that almost all countries comply with WTO rules on public stocks. For instance, when the PS purchases only 2% of national production at a price only 10% higher than the external reference price (ERP) based on the current international price, the real subsidy provided accounts for only 0.2% of the value of national production, which is far below the country *de minimis* (10% of the value of production for developing countries, 5% for developed countries and 8.5% for China). However, because of the biases in WTO rules, more than 88% of the countries are exposed to legal challenge if the subsidy is estimated according to WTO rules (see tables 7 and 8).

We also tested the effect of correcting only some of the biases. It appears that doing so would *not* eliminate the bias on country compliance. One implication of this is that expressing the fixed external reference price (FERP) in US dollars, correcting it with the country inflation rate or replacing it by the average unit value of imports or exports over the last five years (as proposed by several experts and WTO Members) would not be enough to remove the bias on country compliance.
All three biases must therefore be corrected, which can be achieved in a rather simple manner, as shown at the end of this paper.

We hope that having the right metrics on the PS subsidy will help to stimulate discussions on the second debate, related to the maximum allowed subsidy level. Brink (2014b) provides some useful insights in that direction by exploring the implications of the draft modalities arrived at in 2008 under the Doha Development Agenda (WTO 2008).

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Appendix 1. Country base period, de minimis and domestic support limit

The table below displays the base period, the *de minimis* and the domestic support limit (DSL) for the 132 countries of our sample: all 133 WTO Members with domestic support commitments (all WTO Members minus the 28 EU members, as WTO disciplines are applied to the EU as a whole), except Liechtenstein (which is absent from FAOSTAT database, the one we used to calculate country unit values of imports and exports).

The domestic support limit (DSL) is expressed in billion USD (we converted WTO data in various currencies using World Bank data on exchange rates) and as a percentage of the wheat value of production (using FAOSTAT data).

Country	Base period	De minimis	DSL (Total AMS ceiling)	
			(billion USD)	(% of wheat value of production)
Albania	1996-1998	5%	0	0%
Angola	1986-1988	10%	0	0%
Antigua and Barbuda	1986-1988	10%	0	0%
Argentina	1986-1988	10%	0.08	2.33%
Armenia	1995-1997	5%	0	0%
Australia	1986-1988	5%	0.43	5.86%
Bahrain	1986-1988	10%	0	0%
Bangladesh	1986-1988	10%	0	0%
Barbados	1986-1988	10%	0	0%
Belize	1986-1988	10%	0	0%
Benin	1986-1988	10%	0	0%
Bolivia (Plurinational State of)	1986-1988	10%	0	0%
Botswana	1986-1988	10%	0	0%
Brazil	1986-1988	10%	0.91	65.29%
Brunei Darussalam	1986-1988	10%	0	0%
Burkina Faso	1986-1988	10%	0	0%
Burundi	1986-1988	10%	0	0%
Cabo Verde	2003-2005	10%	0	0%
Cambodia	1998-2000	10%	0	0%
Cameroon	1986-1988	10%	0	0%
Canada	1986-1988	5%	3.89	64.98%
Central African Republic	1986-1988	10%	0	0%
Chad	1986-1988	10%	0	0%
Chile	1986-1988	10%	0	0%
China	1996-1998	8.5%	0	0%
China, Hong Kong SAR	1986-1988	n. a.	0	0%
China, Macao SAR	1986-1988	n. a.	0	0%
China, Taiwan Province of	1990-1992	5%	0.47	n. a.
Colombia	1986-1988	10%	0.34	5551.26%
Congo	1986-1988	10%	0	0%

Costa Rica	1986-1988	10%	0.02	n. a.
Côte d'Ivoire	1986-1988	10%	0	0%
Cuba	1986-1988	10%	0	0%
Democratic Republic of the Congo	1986-1988	10%	0	0%
Djibouti	1986-1988	10%	0	0%
Dominica	1986-1988	10%	0	0%
Dominican Republic	1986-1988	10%	0	0%
Ecuador	1986-1988	10%	0	0%
Egypt	1986-1988	10%	0	0%
El Salvador	1986-1988	10%	0	0%
European Union (exc. intra-trade)	1986-1988	5%	89.10	229.10%
Fiji	1986-1988	10%	0	0%
Gabon	1986-1988	10%	0	0%
Gambia	1986-1988	10%	0	0%
Georgia	1996-1998	5%	0	0%
Ghana	1986-1988	10%	0	0%
Grenada	1986-1988	10%	0	0%
Guatemala	1986-1988	10%	0	0%
Guinea	1986-1988	10%	0	0%
Guinea-Bissau	1986-1988	10%	0	0%
Guyana	1986-1988	10%	0	0%
Haiti	1986-1988	10%	0	0%
Honduras	1986-1988	10%	0	0%
Iceland	1986-1988	5%	0.20	n. a.
India	1986-1988	10%	0	0%
Indonesia	1986-1988	10%	0	0%
Israel	1986-1988	10%	0.57	1184.88%
Jamaica	1986-1988	10%	0	0%
Japan	1986-1988	5%	37.50	7926.22%
Jordan	1994-1996	10%	0.00	22.31%
Kenya	1986-1988	10%	0	0%
Kuwait	1986-1988	10%	0	0%
Kyrgyzstan	1994-1996	5%	0	0%
Lao People's Democratic Republic	2001-2003	10%	0	0%
Lesotho	1986-1988	10%	0	0%
Madagascar	1986-1988	10%	0	0%
Malawi	1986-1988	10%	0	0%
Malaysia	1986-1988	10%	0	0%
Maldives	1986-1988	10%	0	0%
Mali	1986-1988	10%	0	0%
Mauritania	1986-1988	10%	0	0%
Mauritius	1986-1988	10%	0	0%
Mexico	1986-1988	10%	1.89	179.66%
Mongolia	1986-1988	10%	0	0%

Montenegro	2005-2007	5%	0.00	n. a.
Morocco	1986-1988	10%	0.08	4.43%
Mozambique	1986-1988	10%	0	0%
Myanmar	1986-1988	10%	0	0%
Namibia	1986-1988	10%	0	0%
Nepal	1995-1997	10%	0	0%
New Zealand	1986-1988	5%	0.24	226.55%
Nicaragua	1986-1988	10%	0	0%
Niger	1986-1988	10%	0	0%
Nigeria	1986-1988	10%	0	0%
Norway	1986-1988	5%	1.82	1496.68%
Oman	1994-1996	10%	0	0%
Pakistan	1986-1988	10%	0	0%
Panama	1991-1993	10%	0	0%
Papua New Guinea	1986-1988	10%	0.03	n. a.
Paraguay	1986-1988	10%	0	0%
Peru	1986-1988	10%	0	0%
Philippines	1986-1988	10%	0	0%
Qatar	1986-1988	10%	0	0%
Republic of Korea	1986-1988	10%	1.42	n. a.
Republic of Moldova	1996-1998	5%	0.02	n. a.
Russian Federation	2006-2008	5%	7.20	73.49%
Rwanda	1986-1988	10%	0	0%
Saint Kitts and Nevis	1986-1988	10%	0	0%
Saint Lucia	1986-1988	10%	0	0%
Saint Vincent and the Grenadines	1986-1988	10%	0	0%
Samoa	2005-2008	10%	0	0%
Saudi Arabia	2001-2003	10%	0.86	n. a.
Senegal	1986-1988	10%	0	0%
Seychelles	2010-2012	10%	0	0%
Sierra Leone	1986-1988	10%	0	0%
Singapore	1986-1988	n. a.	0	0%
Solomon Islands	1986-1988	10%	0	0%
South Africa	1986-1988	5%	0.19	28.22%
Sri Lanka	1986-1988	10%	0	0%
Suriname	1986-1988	10%	0	0%
Swaziland	1986-1988	10%	0	0%
Switzerland	1986-1988	5%	4.65	1618.24%
Tajikistan	2008-2010	10%	0.18	48.27%
Thailand	1986-1988	10%	0.59	
The former Yugoslav Republic of Macedonia	1998-2000	5%	0.02	20.25%
Togo	1986-1988	10%	0	0%
Tonga	1996-1998	10%	0	0%
Trinidad and Tobago	1986-1988	10%	0	0%

Tunisia	1986-1988	10%	0.03	7.13%
Turkey	1986-1988	10%	0	0%
Uganda	1986-1988	10%	0	0%
Ukraine	2004-2006	5%	0.20	5.49%
United Arab Emirates	1986-1988	10%	0	0%
United Republic of Tanzania	1986-1988	10%	0	0%
United States of America	1986-1988	5%	19.10	131.98%
Uruguay	1986-1988	10%	0	0%
Vanuatu	2006-2008	10%	0	0%
Venezuela (Bolivarian Republic of)	1986-1988	10%	1.13	
Viet Nam	1999-2001	10%	0.19	
Yemen	2006-2008	10%	0	0%
Zambia	1986-1988	10%	0	0%
Zimbabwe	1986-1988	10%	0	0%

Sources: WTO for base period, *de minimis* and Total AMS ceiling, The World Bank for exchange rates and FAOSTAT for wheat value of production.

Appendix 2. Estimated values for B1a, B1b, B1c, B1d and B1 by country (for wheat)

Country	B1a	B1b	B1c	B1d	B1 (with B1b included)	B1 (without B1b)
Albania	0.5711	1.0304312008	0.9832	0.87	0.5043238891020	0.4894
Angola	0.0841	0.0000000003	0.9804	1.08	0.0000000000284	0.0891
Antigua and Barbuda	n.a.	1.0000000000	1.0000	1.08	n. a	n. a
Argentina	0.3115	0.0000916546	1.0000	1.35	0.0000385278764	0.4204
Armenia	0.7044	0.9399562372	1.0000	0.75	0.4933669447763	0.5249
Australia	0.3440	1.4560626605	1.0000	1.13	0.5683593705424	0.3903
Bahrain	0.3074	1.0000000000	1.0000	1.08	0.3319477167188	0.3319
Bangladesh	0.3618	0.4200297360	0.9524	1.14	0.1653778157820	0.3937
Barbados	0.4145	1.0000000000	1.0000	1.08	0.4476771917210	0.4477
Belize	0.3479	1.0000000000	1.0000	1.08	0.3757063044308	0.3757
Benin	0.4163	0.6602533405	0.9524	0.96	0.2512796702015	0.3806
Bolivia (Plurinational State of)	0.4751	0.2993726922	0.9864	1.14	0.1603288812431	0.5355
Botswana	0.3330	0.2656291492	1.0000	0.87	0.0769559044634	0.2897
Brazil	0.3609	0.0000000168	0.9967	1.14	0.0000000068863	0.4104
Brunei Darussalam	0.5880	1.6833159177	1.0000	1.08	1.0688853268558	0.6350
Burkina Faso	0.3775	0.6668569761	0.9524	0.87	0.2085856899159	0.3128
Burundi	1.0759	0.1001088736	0.9149	0.87	0.0857368970148	0.8564
Cabo Verde	0.5524	1.2747515830	0.9524	0.96	0.6438702751372	0.5051
Cambodia	0.9146	0.8728870638	0.9346	0.96	0.7162614652870	0.8206
Cameroon	0.4192	0.6574995465	0.9972	0.96	0.2638508725157	0.4013
Canada	0.3953	1.3243786754	1.0000	1.44	0.7514458727721	0.5674
Central African Republic	n.a.	0.6673437348	n. a		n. a	n. a
Chad	1.6361	0.7339071258	0.9091	0.87	0.9496660086321	1.2940
Chile	0.4383	0.4339255769	0.9634	1.02	0.1860764577597	0.4288
China	0.5689	1.2897257620	0.6061	1.80	0.8023859113256	0.6221
China, Hong Kong SAR	0.3360	1.0023723608	1.0000	1.08	0.3637280809480	0.3629

China, Macao SAR	n.a.	1.0003713770	1.0000	1.08	n. a	n. a
China, Taiwan Province of	0.4140	0.9089709644	0.9390	1.08	0.3816114481612	0.4198
Colombia	0.3675	0.1327102521	0.9343	0.74	0.0336129506108	0.2533
Congo	0.6834	0.6632134602	0.9091	0.96	0.3955459602779	0.5964
Costa Rica	0.4123	0.1288041788	1.0000	1.08	0.0573499728171	0.4452
Côte d'Ivoire	0.4188	0.6660203480	0.9524	0.96	0.2550122741705	0.3829
Cuba	0.2981	n.a.	0.9951	1.08	n. a	0.3204
Democratic Republic of the Congo	0.4483	0.0000000000	0.9302	0.96	0.0000000000002	0.4003
Djibouti	0.3061	1.0000000000	0.9901	0.96	0.2909057952836	0.2909
Dominica	n.a.	1.0000000000	n. a		n. a	n. a
Dominican Republic	0.3559	0.1125149721	1.0000	1.08	0.0432456712235	0.3844
Ecuador	0.4311	n.a.	0.9489	1.02	n. a	0.4191
Egypt	0.4151	0.1179877018	1.0000	0.79	0.0385415607116	0.3267
El Salvador	0.3929	0.5638132641	1.0000	0.96	0.2126407747998	0.3771
European Union (exc. intra-trade)	0.3263	2.6983049002	1.0000	1.26	1.1094993283181	0.4112
Fiji	0.2833	0.7042990263	1.0000	1.08	0.2154882929628	0.3060
Gabon	0.4232	0.6684302895	0.9524	1.08	0.2909433170481	0.4353
Gambia	n.a.	0.2342919893	0.8333	0.96	n. a	n. a
Georgia	0.6359	0.4875399260	1.0000	0.91	0.2827526762503	0.5800
Ghana	0.2964	0.0106555545	0.9091	0.96	0.0027564436196	0.2587
Grenada	0.4014	1.0000000000	1.0000	1.08	0.4335407688877	0.4335
Guatemala	0.4746	0.3031106545	1.0000	0.96	0.1380954171193	0.4556
Guinea	n.a.	0.0618927120	0.9524	0.96	n. a	n. a
Guinea-Bissau	n.a.	0.0203484853	n. a		n. a	n. a
Guyana	0.1770	0.0439126662	1.0000	0.96	0.0074635351832	0.1700
Haiti	0.5470	0.1233872608	0.9999	0.96	0.0647827959106	0.5250
Honduras	0.3580	0.1057242175	1.0000	0.96	0.0363383946130	0.3437
Iceland	0.5835	0.3636183312	0.7843	1.08	0.1797254154928	0.4943
India	0.6077	0.2958615236	1.0000	1.26	0.2265254747960	0.7656

Indonesia	0.3878	0.1754085647	0.9537	0.96	0.0622819132113	0.3551
Israel	0.4692	0.4358156454	0.8244	1.08	0.1820306934746	0.4177
Jamaica	0.4047	0.0638527050	1.0000	1.08	0.0279073002888	0.4371
Japan	0.3725	1.8420283818	0.8277	0.72	0.4075385471332	0.2212
Jordan	0.4447	0.9818977607	1.0000	0.56	0.2448821157618	0.2494
Kenya	0.3761	0.1872407347	0.9533	0.74	0.0499901701181	0.2670
Kuwait	0.3294	1.0223723832	1.0000	1.08	0.3637625835277	0.3558
Kyrgyzstan	0.9569	0.1609516510	1.0000	0.83	0.1270683762413	0.7895
Lao People's Democratic Republic	n.a.	1.2278850795	n. a		n. a	n. a
Lesotho	1.0155	0.3045316469	1.0000	0.87	0.2690583263572	0.8835
Madagascar	0.4258	0.1061727127	0.9681	0.96	0.0420181169316	0.3958
Malawi	0.4527	0.0144634905	1.0000	0.87	0.0056960343219	0.3938
Malaysia	0.3857	0.8419412888	1.0000	1.08	0.3507176807913	0.4166
Maldives	0.0302	0.5410404088	0.8733	1.08	0.0153856813266	0.0284
Mali	0.5374	0.6651500558	0.9542	0.87	0.2967117587242	0.4461
Mauritania	0.4484	0.2650289512	0.9792	0.96	0.1117115456635	0.4215
Mauritius	0.8509	0.4638126601	1.0000	1.08	0.4262341329490	0.9190
Mexico	0.3611	0.1498573017	0.9929	1.17	0.0626353390914	0.4180
Mongolia	1.2726	n.a.	0.9524	0.72	n. a	0.8728
Montenegro	0.5813	1.1138903023	1.0000	1.08	0.6992872546209	0.6278
Morocco	0.3018	1.0545903980	0.8236	1.21	0.3172641991849	0.3008
Mozambique	0.7025	0.0119721117	0.9756	0.96	0.0078767339702	0.6579
Myanmar	n.a.	1.2477321304	1.0000	0.96	n. a	n. a
Namibia	0.3135	0.3014961495	1.0000	1.08	0.1020772050110	0.3386
Nepal	1.3406	0.6739075470	0.9104	0.87	0.7188217741060	1.0666
New Zealand	0.4687	1.3170792017	1.0000	1.12	0.6939954526542	0.5269
Nicaragua	0.4761	0.0000009469	1.0000	0.96	0.0000004327603	0.4570
Niger	0.6095	0.6369098228	0.9528	0.87	0.3217750325514	0.5052
Nigeria	0.5386	0.0151600280	0.9524	1.43	0.0111570529983	0.7360

Norway	0.3327	1.2314105709	0.4538	1.73	0.3212050947109	0.2608
Oman	0.4571	0.9999999874	1.0000	1.08	0.4936945509834	0.4937
Pakistan	0.5003	0.1972112422	1.0000	1.15	0.1129782065696	0.5729
Panama	0.4867	1.0000000000	1.0000	1.08	0.5256460608947	0.5256
Papua New Guinea	0.3836	0.3840341475	1.0000	0.96	0.1414262942481	0.3683
Paraguay	0.3657	0.1157432658	1.0000	1.11	0.0469721284092	0.4058
Peru	0.3818	0.0000179348	0.9837	0.72	0.0000048214809	0.2688
Philippines	0.4328	0.4782020317	0.9772	0.96	0.1941465846467	0.4060
Qatar	0.4622	1.0000000000	1.0000	1.08	0.4992287090299	0.4992
Republic of Korea	0.3767	0.7289209594	0.9829	1.08	0.2914718530434	0.3999
Republic of Moldova	0.6907	0.3901005231	1.0000	1.42	0.3837753987447	0.9838
Russian Federation	0.9043	0.9175818507	1.0000	1.31	1.0883020553735	1.1861
Rwanda	0.9542	0.1310313015	1.0000	0.66	0.0825351331814	0.6299
Saint Kitts and Nevis	n.a.	1.0000000000	n. a		n. a	n. a
Saint Lucia	n.a.	1.0000000000	1.0000	1.08	n. a	n. a
Saint Vincent and the Grenadines	0.3501	1.0000000000	1.0000	1.08	0.3780543880315	0.3781
Samoa	n.a.	1.1290632461	n. a		n. a	n. a
Saudi Arabia	1.2712	1.0000000000	1.0000	0.82	1.0454367279968	1.0454
Senegal	0.3923	0.6644635066	0.9524	0.96	0.2383299875498	0.3587
Seychelles	0.8671	1.0415789473	1.0000	1.08	0.9754246087542	0.9365
Sierra Leone	0.5246	0.0064033656	0.9524	0.96	0.0030714310951	0.4797
Singapore	0.3402	1.6553416694	1.0000	1.08	0.6082475629084	0.3674
Solomon Islands	0.7367	0.2725341706	0.9524	0.96	0.1835744210717	0.6736
South Africa	0.3747	0.3064492521	1.0000	0.96	0.1106144888741	0.3610
Sri Lanka	0.3781	0.2695388297	0.9457	0.96	0.0925362564342	0.3433
Suriname	0.3511	0.0005462056	1.0000	1.08	0.0002071370032	0.3792
Swaziland	0.8209	0.3056257808	1.0000	0.87	0.2182860007247	0.7142
Switzerland	0.4254	1.7860235371	0.6922	1.16	0.6082803316057	0.3406
Tajikistan	0.8982	0.8061398621	1.0000	0.48	0.3487567894550	0.4326

Thailand	0.4574	0.8420344669	0.7874	1.08	0.3275463223170	0.3890
The former Yugoslav Republic of Macedonia	0.4234	1.2367002273	0.9207	1.21	0.5813715488246	0.4701
Togo	0.4685	0.6571706299	0.9524	0.96	0.2814911264735	0.4283
Tonga	n.a.	0.7687800034	n. a		n. a	n. a
Trinidad and Tobago	0.3191	0.5724935172	1.0000	1.08	0.1973173944599	0.3447
Tunisia	0.3672	0.5900587727	0.6856	1.53	0.2273677982575	0.3853
Turkey	0.2884	0.0008026503	0.6144	1.42	0.0002025210011	0.2523
Uganda	0.4038	0.0281946457	0.9402	0.87	0.0093119494871	0.3303
Ukraine	0.4446	0.6593175164	1.0000	1.42	0.4154276134885	0.6301
United Arab Emirates	0.4167	0.9995915589	1.0000	1.08	0.4498605042109	0.4500
United Republic of Tanzania	0.3619	0.0384036348	0.9403	0.96	0.0125453113977	0.3267
United States of America	0.3367	1.0000000000	1.0000	1.27	0.4281936668478	0.4282
Uruguay	0.4497	0.0097661738	1.0000	1.03	0.0045137775800	0.4622
Vanuatu	n.a.	1.1449475145	n. a		n. a	n. a
Venezuela (Bolivarian Republic of)	0.4072	0.0029507670	0.9015	1.08	0.0011698530474	0.3965
Viet Nam	0.4200	0.6775563932	0.9870	0.96	0.2696489246538	0.3980
Yemen	0.8189	0.9151212348	1.0000	0.48	0.3595223912371	0.3929
Zambia	0.3485	0.0017252602	0.9639	0.87	0.0005041683937	0.2922
Zimbabwe	0.2828	n.a.	0.9900	0.87	n. a	0.2435

Appendix 3. Formulas to simulate the effect on s_{WTO} of correcting B1, B2 and B3

	Scenarios on WTO rules correction	s_{WTO}	s	BS = s_{WTO} / s
1	No correction [remaining biases: B1 + B2 + B3]	[1 + ß – B1] / [1 + ß γ]	ß [α + (δ - α) γ] / [1 + ß γ]	[1 + ß – B1] / ß [α + (δ - α) γ]
2	Correcting B1 [remaining biases: B2 + B3]	ß / [1 + ß γ]	ß [α + (δ - α) γ] / [1 + ß γ]	1 / [α + (δ - α) γ]
3	Correcting B2 [remaining biases: B1 + B3]	[1 + ß – B1] [α + (1 - α) γ] / [1 + ß γ]	ß [α + (δ - α) γ] / [1 + ß γ]	[1 + ß – B1] [α + (1 - α) γ] / ß [α + (δ - α) γ]
4	Correcting B3 [remaining biases: B1 + B2]	δ [1 + ß – B1] / [1 + ß γ]	ß [α + (δ - α) γ] / [1 + ß γ]	δ [1 + ß – B1] / ß [α + (δ - α) γ]
5	Correcting B1 and B2 [remaining bias: B3]	ß [α + (1 - α) γ] / [1 + ß γ]	ß [α + (δ - α) γ] / [1 + ß γ]	[α + (1 - α) γ] / [α + (δ - α) γ]
6	Correcting B1 and B3 [remaining bias: B2]	ß δ / [1 + ß γ]	ß [α + (δ - α) γ] / [1 + ß γ]	δ / [α + (δ - α) γ]
7	Correcting B2 and B3 [remaining bias: B1]	[1 + ß – B1] [α + (δ - α) γ] / [1 + ß γ]	ß [α + (δ - α) γ] / [1 + ß γ]	[1 + ß – B1] / ß
8	Correcting B1, B2 and B3 [remaining bias: none]	ß [α + (δ - α) γ] / [1 + ß γ]	ß [α + (δ - α) γ] / [1 + ß γ]	1

Appendix 4. Bias on compliance when B1 is partially corrected (correction of B1a and B1b)

Table A. Frequency of type 1 error and type 2 error by scenario (for all countries)

Scenarios					Effect on country compliance with B1 uncorrected		Effect on country compliance with B1 partially corrected	
	α	ß	γ	δ	Type 1 error	Type 2 error	Type 1 error	Type 2 error
1	2%	10%	0%	80%	[88%, 97%]	0%	[53%, 59%]	0%
2	2%	10%	0%	100%	[88%, 97%]	0%	[53%, 59%]	0%
3	2%	50%	0%	80%	[90%, 100%]	0%	[89%, 100%]	0%
4	2%	50%	0%	100%	[90%, 100%]	0%	[89%, 100%]	0%
5	20%	10%	0%	80%	[88%, 97%]	0%	[53%, 59%]	0%
6	20%	10%	0%	100%	[88%, 97%]	0%	[53%, 59%]	0%
7	20%	10%	50%	80%	[88%, 97%]	0%	[52%, 58%]	0%
8	20%	10%	50%	100%	[80%, 86%]	[0%, 2%]	[49%, 50%]	[1%, 8%]
9	20%	10%	100%	80%	[80%, 85%]	[0%, 2%]	[49%, 50%]	[2%, 8%]
10	20%	10%	100%	100%	[79%, 84%]	[0%, 2%]	[49%, 50%]	[3%, 9%]
11	20%	50%	0%	80%	[80%, 86%]	0%	[80%, 86%]	0%
12	20%	50%	0%	100%	[80%, 86%]	0%	[80%, 86%]	0%
13	20%	50%	50%	80%	[0%, 5%]	0%	[0%, 4%]	0%
14	20%	50%	50%	100%	[0%, 3%]	0%	[0%, 2%]	0%
15	20%	50%	100%	80%	[0%, 3%]	0%	[0%, 2%]	[1%, 2%]
16	20%	50%	100%	100%	[0%, 2%]	0%	[0%, 1%]	[1%, 2%]

Table B. Frequency of type 1 error and type 2 error by scenario (for exporters and importers)

Scenarios					Effect on country compliance with B1 partially corrected			
					Exporters		Importers	
	α	ß	γ	δ	Type 1 error	Type 2 error	Type 1 error	Type 2 error
1	2%	10%	0%	80%	0%	0%	[60%, 66%]	0%
2	2%	10%	0%	100%	0%	0%	[60%, 66%]	0%
3	2%	50%	0%	80%	[64%, 100%]	0%	[91%, 100%]	0%
4	2%	50%	0%	100%	[64%, 100%]	0%	[91%, 100%]	0%
5	20%	10%	0%	80%	0%	0%	[60%, 66%]	0%
6	20%	10%	0%	100%	0%	0%	[60%, 66%]	0%
7	20%	10%	50%	80%	0%	0%	[59%, 65%]	0%
8	20%	10%	50%	100%	0%	[9%, 55%]	[54%, 56%]	[0%,2%]
9	20%	10%	100%	80%	0%	[18%, 55%]	[54%, 56%]	[0%,2%]
10	20%	10%	100%	100%	0%	[18%, 55%]	[54%, 56%]	[1%,3%]
11	20%	50%	0%	80%	45%	0%	[84%, 90%]	0%
12	20%	50%	0%	100%	45%	0%	[84%, 90%]	0%
13	20%	50%	50%	80%	0%	0%	[0%, 4%]	0%
14	20%	50%	50%	100%	0%	0%	[0%,2%]	0%
15	20%	50%	100%	80%	0%	[0%, 9%]	[0%,2%]	1%
16	20%	50%	100%	100%	0%	[0%, 9%]	[0%, 1%]	1%

Appendix 5. Bias on compliance when B1 is (fully) corrected

Scenarios					Effect on country compliance with B1 uncorrected		Effect on country compliance with B1 fully corrected	
	α	ß	γ	δ	Type 1 error	Type 2 error	Type 1 error	Type 2 error
1	2%	10%	0%	80%	[88%, 97%]	0%	[7%, 16%]	0%
2	2%	10%	0%	100%	[88%, 97%]	0%	[7%, 16%]	0%
3	2%	50%	0%	80%	[90%, 100%]	0%	[89%,100%]	0%
4	2%	50%	0%	100%	[90%, 100%]	0%	[89%,100%]	0%
5	20%	10%	0%	80%	[88%, 97%]	0%	[7%, 16%]	0%
6	20%	10%	0%	100%	[88%, 97%]	0%	[7%, 16%]	0%
7	20%	10%	50%	80%	[88%, 97%]	0%	[7%, 16%]	0%
8	20%	10%	50%	100%	[80%, 86%]	[0%, 2%]	[1%, 2%]	0%
9	20%	10%	100%	80%	[80%, 85%]	[0%, 2%]	1%	0%
10	20%	10%	100%	100%	[79%, 84%]	[0%, 2%]	0%	0%
11	20%	50%	0%	80%	[80%, 86%]	0%	[80%, 86%]	0%
12	20%	50%	0%	100%	[80%, 86%]	0%	[80%, 86%]	0%
13	20%	50%	50%	80%	[0%, 5%]	0%	[0%, 3%]	0%
14	20%	50%	50%	100%	[0%, 3%]	0%	[0%, 1%]	0%
15	20%	50%	100%	80%	[0%, 3%]	0%	[0%, 1%]	0%
16	20%	50%	100%	100%	[0%, 2%]	0%	0%	0%

Appendix 6. Bias on compliance when B2 is corrected

Table A. Case where B1 includes the exchange rate bias

Scenarios					Impact on country compliance with B2 uncorrected		Impact on country compliance with B2 corrected	
	α	ß	γ	δ	Type 1 error	Type 2 error	Type 1 error	Type 2 error
1	2%	10%	0%	80%	[88%, 97%]	0%	0%	0%
2	2%	10%	0%	100%	[88%, 97%]	0%	0%	0%
3	2%	50%	0%	80%	[90%, 100%]	0%	0%	0%
4	2%	50%	0%	100%	[90%, 100%]	0%	0%	0%
5	20%	10%	0%	80%	[88%, 97%]	0%	[77%, 91%]	0%
6	20%	10%	0%	100%	[88%, 97%]	0%	[77%, 91%]	0%
7	20%	10%	50%	80%	[88%, 97%]	0%	[84%, 95%]	0%
8	20%	10%	50%	100%	[80%, 86%]	[0%, 2%]	[76%, 84%]	[0%, 2%]
9	20%	10%	100%	80%	[80%, 85%]	[0%, 2%]	[80%, 85%]	[0%, 2%]
10	20%	10%	100%	100%	[79%, 84%]	[0%, 2%]	[79%, 84%]	[0%, 2%]
11	20%	50%	0%	80%	[80%, 86%]	0%	[77%, 82%]	0%
12	20%	50%	0%	100%	[80%, 86%]	0%	[77%, 82%]	0%
13	20%	50%	50%	80%	[0%, 5%]	0%	[0%, 5%]	0%
14	20%	50%	50%	100%	[0%, 3%]	0%	[0%, 3%]	0%
15	20%	50%	100%	80%	[0%, 3%]	0%	[0%, 3%]	0%
16	20%	50%	100%	100%	[0%, 2%]	0%	[0%, 2%]	0%

Table B. Case where B1 does not include the exchange rate bias

Scenarios					Impact on country compliance with B2 uncorrected		Impact on country compliance with B2 corrected	
	α	ß	γ	δ	Type 1 error	Type 2 error	Type 1 error	Type 2 error
1	2%	10%	0%	80%	[88%, 97%]	0%	0%	0%
2	2%	10%	0%	100%	[88%, 97%]	0%	0%	0%
3	2%	50%	0%	80%	[90%, 100%]	0%	0%	0%
4	2%	50%	0%	100%	[90%, 100%]	0%	0%	0%
5	20%	10%	0%	80%	[88%, 97%]	0%	[70%, 85%]	0%
6	20%	10%	0%	100%	[88%, 97%]	0%	[70%, 85%]	0%
7	20%	10%	50%	80%	[88%, 97%]	0%	[85%, 96%]	0%
8	20%	10%	50%	100%	[80%, 86%]	[0%, 1%]	[77%, 85%]	[0%, 1%]
9	20%	10%	100%	80%	[79%, 85%]	[0%, 1%]	[79%, 85%]	[0%, 1%]
10	20%	10%	100%	100%	[78%, 84%]	[0%, 1%]	[78%, 84%]	[0%, 1%]
11	20%	50%	0%	80%	[81%, 87%]	0%	[77%, 83%]	0%
12	20%	50%	0%	100%	[81%, 87%]	0%	[77%, 83%]	0%
13	20%	50%	50%	80%	[0%, 6%]	0%	[0%, 4%]	1%
14	20%	50%	50%	100%	[0%, 4%]	0%	[0%, 2%]	1%
15	20%	50%	100%	80%	[0%, 3%]	0%	[0%, 3%]	0%
16	20%	50%	100%	100%	[0%, 2%]	0%	[0%, 2%]	0%

Appendix 7. Bias on compliance when B3 is corrected

Table A. Case where B1 includes the exchange rate bias

Scenarios					Impact on country compliance with B3 uncorrected		Impact on country compliance with B3 corrected	
	α	ß	γ	δ	Type 1 error	Type 2 error	Type 1 error	Type 2 error
1	2%	10%	0%	80%	[88%, 97%]	0%	[87%, 96%]	0%
2	2%	10%	0%	100%	[88%, 97%]	0%	[88%, 97%]	0%
3	2%	50%	0%	80%	[90%, 100%]	0%	[89%, 100%]	0%
4	2%	50%	0%	100%	[90%, 100%]	0%	[90%, 100%]	0%
5	20%	10%	0%	80%	[88%, 97%]	0%	[87%, 96%]	0%
6	20%	10%	0%	100%	[88%, 97%]	0%	[88%, 97%]	0%
7	20%	10%	50%	80%	[88%, 97%]	0%	[87%, 96%]	0%
8	20%	10%	50%	100%	[80%, 86%]	[0%, 2%]	[80%, 86%]	[0%, 2%]
9	20%	10%	100%	80%	[80%, 85%]	[0%, 2%]	[79%, 84%]	[0%, 2%]
10	20%	10%	100%	100%	[79%, 84%]	[0%, 2%]	[79%, 84%]	[0%, 2%]
11	20%	50%	0%	80%	[80%, 86%]	0%	[80%, 85%]	0%
12	20%	50%	0%	100%	[80%, 86%]	0%	[80%, 86%]	0%
13	20%	50%	50%	80%	[0%, 5%]	0%	[0%, 5%]	0%
14	20%	50%	50%	100%	[0%, 3%]	0%	[0%, 3%]	0%
15	20%	50%	100%	80%	[0%, 3%]	0%	[0%, 3%]	0%
16	20%	50%	100%	100%	[0%, 2%]	0%	[0%, 2%]	0%

Table B. Case where B1 does not include the exchange rate bias

Scenarios					Impact on country compliance with B3 uncorrected		Impact on country compliance with B3 corrected	
	α	ß	γ	δ	Type 1 error	Type 2 error	Type 1 error	Type 2 error
1	2%	10%	0%	80%	[88%, 97%]	0%	[87%, 97%]	0%
2	2%	10%	0%	100%	[88%, 97%]	0%	[88%, 97%]	0%
3	2%	50%	0%	80%	[90%, 100%]	0%	[90%, 100%]	0%
4	2%	50%	0%	100%	[90%, 100%]	0%	[90%, 100%]	0%
5	20%	10%	0%	80%	[88%, 97%]	0%	[87%, 97%]	0%
6	20%	10%	0%	100%	[88%, 97%]	0%	[88%, 97%]	0%
7	20%	10%	50%	80%	[88%, 97%]	0%	[87%, 97%]	0%
8	20%	10%	50%	100%	[80%, 86%]	[0%, 1%]	[80%, 86%]	[0%, 1%]
9	20%	10%	100%	80%	[79%, 85%]	[0%, 1%]	[79%, 85%]	[0%, 1%]
10	20%	10%	100%	100%	[78%, 84%]	[0%, 1%]	[78%, 84%]	[0%, 1%]
11	20%	50%	0%	80%	[81%, 87%]	0%	[81%, 87%]	0%
12	20%	50%	0%	100%	[81%, 87%]	0%	[81%, 87%]	0%
13	20%	50%	50%	80%	[0%, 6%]	0%	[0%, 5%]	0%
14	20%	50%	50%	100%	[0%, 4%]	0%	[0%, 4%]	0%
15	20%	50%	100%	80%	[0%, 3%]	0%	[0%, 2%]	0%
16	20%	50%	100%	100%	[0%, 2%]	0%	[0%, 2%]	0%

Appendix 8. Bias on compliance when B1 and B2 are corrected

Scenarios					Impact on country compliance with B1 (B1_abcd), B2 and B3		Impact on country compliance with B3	
	α	ß	γ	δ	Type 1 error	Type 2 error	Type 1 error	Type 2 error
1	2%	10%	0%	80%	[88%, 97%]	0%	0%	0%
2	2%	10%	0%	100%	[88%, 97%]	0%	0%	0%
3	2%	50%	0%	80%	[90%, 100%]	0%	0%	0%
4	2%	50%	0%	100%	[90%, 100%]	0%	0%	0%
5	20%	10%	0%	80%	[88%, 97%]	0%	0%	0%
6	20%	10%	0%	100%	[88%, 97%]	0%	0%	0%
7	20%	10%	50%	80%	[88%, 97%]	0%	[5%, 15%]	0%
8	20%	10%	50%	100%	[80%, 86%]	[0%, 2%]	0%	0%
9	20%	10%	100%	80%	[80%, 85%]	[0%, 2%]	1%	0%
10	20%	10%	100%	100%	[79%, 84%]	[0%, 2%]	0%	0%
11	20%	50%	0%	80%	[80%, 86%]	0%	0%	0%
12	20%	50%	0%	100%	[80%, 86%]	0%	0%	0%
13	20%	50%	50%	80%	[0%, 5%]	0%	[0%, 2%]	0%
14	20%	50%	50%	100%	[0%, 3%]	0%	0%	0%
15	20%	50%	100%	80%	[0%, 3%]	0%	[0%, 1%]	0%
16	20%	50%	100%	100%	[0%, 2%]	0%	0%	0%

Appendix 9. Is the Olympic average of import or export unit values over the last five years a good predictor variable of the next year unit value?

The following table displays the error introduced by using the Olympic average of import or export unit values over the last five years ($OAUV_{Y-5\ to\ Y-1}$) as a proxy for the next year unit value (UV_Y). The error is defined by ERR = UV_Y / $OAUV_{Y-5\ to\ Y-1.}$ The table gives the average and standard deviation of ERR over the period 2000-2012. We calculated $OA(UV)_{Y-5\ to\ Y-1}$ (for wheat) for the 89 countries for which we had a complete data set on unit values for the period (2000-2012). Average [ERR] > 1 (which is the case for all countries) means that most of the time, the Olympic average of the five preceding years is lower than UV_Y (defining UV* by $OAUV_{Y-5\ to\ Y-1}$ would therefore lead to the external reference price PP* being underestimated and, as a result, to the subsidy procured by public stocks being overestimated).

Country	Average [ERR]	Standard deviation [ERR]
Argentina	1.73	0.80
Australia	1.09	0.19
Bahrain	1.28	0.53
Bangladesh	1.36	0.39
Barbados	1.24	0.32
Belize	1.23	0.47
Benin	1.16	0.25
Bolivia (Plurinational State of)	1.17	0.27
Botswana	1.33	0.81
Brazil	1.28	0.31
Burkina Faso	1.12	0.26
Cabo Verde	1.27	0.35
Cameroon	1.16	0.22
Canada	1.13	0.30
Chile	1.21	0.24
China	1.11	0.31
China, Hong Kong SAR	1.20	0.31
China, Taiwan Province of	1.20	0.30
Colombia	1.27	0.27
Congo	1.18	0.25
Costa Rica	1.44	0.44
Côte d'Ivoire	1.12	0.20
Democratic Republic of the Congo	10.76	20.98
Dominican Republic	1.65	0.77
Egypt	1.35	0.23
El Salvador	1.18	0.36
Fiji	1.32	0.48
Gabon	1.07	0.13
Ghana	1.93	1.00
Grenada	1.19	0.41

Guatemala	1.24	0.29
Guyana	1.50	0.42
Honduras	1.30	0.28
Iceland	1.33	0.43
India	1.26	0.36
Indonesia	1.37	0.38
Israel	1.20	0.25
Jamaica	1.46	0.43
Japan	1.13	0.37
Jordan	1.21	0.42
Kenya	1.21	0.30
Kuwait	1.22	0.35
Lesotho	1.19	0.27
Malaysia	1.23	0.64
Mali	1.08	0.25
Mauritius	1.33	0.37
Mexico	1.32	0.33
Morocco	1.16	0.21
Mozambique	1.43	0.40
Namibia	1.38	0.44
New Zealand	1.11	0.35
Nicaragua	1.46	0.49
Niger	1.02	0.44
Nigeria	1.70	0.61
Norway	1.16	0.22
Oman	1.28	0.55
Pakistan	1.48	0.53
Panama	1.21	0.32
Papua New Guinea	1.25	0.30
Paraguay	1.32	0.32
Peru	1.18	0.27
Philippines	1.23	0.21
Qatar	1.18	0.51
Republic of Korea	1.25	0.42
Saint Vincent and the Grenadines	1.25	0.22
Saudi Arabia	1.11	0.42
Senegal	1.09	0.23
Seychelles	1.86	2.15
Sierra Leone	1.39	0.35
Singapore	1.14	0.26
Solomon Islands	1.26	0.27
South Africa	1.31	0.37
Sri Lanka	1.43	0.33
Suriname	1.54	0.61
Switzerland	1.04	0.17

Thailand	1.14	0.24
Togo	1.10	0.26
Trinidad and Tobago	1.30	0.50
Tunisia	1.30	0.45
Turkey	2.05	1.06
Uganda	1.21	0.14
United Arab Emirates	1.19	0.46
United Republic of Tanzania	1.36	0.34
United States of America	1.24	0.34
Uruguay	1.34	0.45
Venezuela (Bolivarian Republic of)	1.91	0.59
Viet Nam	1.33	0.35
Yemen	1.63	0.56
Zambia	1.51	0.62

[1] Debates concerning WTO rules on PS have been launched through several proposals made by WTO Members: the proposal made in November 2012 by the G33, the May 2013 "non-paper" circulated by a subset of G33 Members, and the September 2013 "non-paper" also proposed by a subset of G33 Members.

The November 2012 initiative proposed "allowing food purchased at administered prices (above prevailing domestic market prices) from low-income or resource-poor producers to be exempt from countries' maximum permitted ceiling on trade-distorting support at the WTO" (Bellman et al., 2013, p.2).

The May 2013 non-paper "identified four variables that could potentially be modified or clarified so as to provide developing countries with greater flexibility under WTO rules. These included the '*de minimis*' ceiling (which is set at ten percent of the value of production for most developing countries), and three elements used to calculate countries' levels of market price support: the external reference price, which is based on a 1986-88 benchmark; the volume of eligible production; and the level of administered prices" (Bellman et al., 2013, p.2).

The September 2013 non-paper proposed the two following options: "The first option would be to agree that developing countries could use a three-year rolling average to calculate how much their food stockholding purchases contributed towards their overall farm subsidy limit, instead of benchmarking support against the external reference price. Countries should also be allowed to use last year's average price in the largest 1-3 suppliers of foodstuffs in the country, the group suggested. The second option would be to agree a draft decision allowing WTO members to take into account excessive rates of inflation – higher than 4 percent, the group suggested – in calculating the contribution of food stockholding programmes towards overall farm subsidy commitments at the WTO" (Bellman et al., 2013, p.2).

[2] In fact, before the Bali WTO Ministerial Conference (December 2013), the debates were actually organised in this way by the chairperson of the agriculture negotiations, New Zealand's Ambassador, John Adank. Ambassador Adank asked WTO members four questions, two of which were related to rules on PS. "Question 3" concerned the rules that define the way the contribution of public stocks to AMS is calculated. "Question 4" was related to safeguard clauses allowing countries to exceed their AMS ceiling (under specific threshold conditions). For more details on the four questions, see http://www.wto.org/english/news_e/news13_e/agng_18jul13_e.htm#q4.

[3] It is worth noting that, as stated by Brink (2007, p. 5), "Annex 2 does not define the 'trade-distorting effects or effects on production' mentioned in the fundamental requirement, nor is there any jurisprudence on its legal meaning. The legal character of the AoA and its Annex 2 may define trade-distorting effects differently from how an economic analyst would define them. Where an economic analysis of a measure finds distorting effects on trade, a legal analysis under Annex 2 may fail to find such effects. The measure would then be exempt from domestic support commitment, in spite of the economic evidence of its trade-distorting effects. Likewise, where economic analysis finds that a measure has no or minimal trade-distorting effects or effects on production, a legal analysis may find that the measure does not meet all the requirements of Annex 2 and is therefore not exempt."

[4] Developed country Members had six years (from the date of their accession) to make the adjustment and developing country Members had 10 years.

[5] The text of the AoA (Article 1.a.ii) says that AMS should be calculated by "*taking into account* [our emphasis] the constituent data and methodology used in the tables of supporting material incorporated by reference in Part IV of the Member's Schedule [meaning country notification for the base period]", which seems to give countries some flexibility. However, Article 1.h.ii mentions that the current Total AMS should be "calculated in accordance with the provisions of this Agreement, including Article 6, and *with* the constituent data and

methodology used in the tables of supporting material incorporated by reference in Part IV of the Member's Schedule" [our emphasis on with].

[6] Note that in all cases, the semantic meaning of "eligible" implies that only quantities that fulfil the conditions to be sold to the public stock should be included (e.g. specific qualities, specific categories of farmers, specific regions of the country).

[7] WTO jurisprudence is compiled in the third edition of the *WTO Analytical Index* (WTO, 2011, which covers developments in WTO law and practice from 1 January 1995 to 30 September 2011) and by the *Analytical Index Supplement Covering New Developments in WTO Law and Practice* (WTO, 2015b), which covers developments after 30 September 2011 and is updated in electronic form on an ongoing basis to reflect new jurisprudence and other significant developments. According to these documents, nine cases concerning the AoA have been addressed (see WTO, 2011, p. 192), the Korea beef case being the only one dealing with domestic support.

[8] For importing countries, the estimation of the TTC is rather more complex than for exporting countries because imported commodities usually do not reach farmers or rural markets: they stay at the level of towns where they compete with supplies from local farmers. The TTC between importers at the border and farmers on rural markets can therefore be estimated by *adding* the TTC between the port and the towns supplied by imports and by *substracting* the TTC between rural markets (where farmers sell their production) and these towns. The TTC between importers at the border and farmers on rural markets can therefore be positive or negative, depending on the value of its two components. However, for landlocked importing countries, the TTC is likely to be > 0 because of the huge transport cost between the port and the country's areas of consumption. Our estimation of the TTC for wheat (expressed as a % of the wholesale price at the port) is equal to 20% for net wheat exporting countries, 13% for landlocked net wheat importing countries and close to zero for other net wheat importing countries.

[9] Of the current 161 WTO Members, only 133 have domestic support commitments at the WTO: the 28 EU Members do not, as these commitments are at the EU level.

[10] http://data.worldbank.org/indicator/PA.NUS.FCRF

[11] To estimate B1c for net wheat exporting countries, we need data on export subsidies and export taxes. Unfortunately, almost no data are available on export taxes (mainly because there is no discipline on export taxes at the WTO). Regarding export subsidies, WTO data on export subsidy commitments show that only five countries are allowed to implement export subsidies on wheat: the EU, Mexico, South Africa, Turkey and the US. Of these Members, only the US and the EU were net wheat exporters in 2011. Since in that year they did not provide any subsidies to wheat exports, we considered that the export subsidy rate s_X was zero for all net wheat exporting Members.

[12] To estimate B1c for net wheat importing countries, we theoretically need data on import taxes and import subsidies. Unfortunately, almost no data are available on import subsidies (mainly because there are no disciplines on them at the WTO and therefore no obligation to notify). This may not be a problem as import subsidies are rarely implemented (even during the 2007-2008 price crisis, many countries removed import taxes, but very few – if any – subsidised imports). Regarding import taxes, the simplest way to proceed is to use the most-favoured nation (MFN) tariff. MFN tariffs by country, commodity and year are provided by the WTO in the IDB database. The problem is that this tariff is not applied to all imports: because of bilateral or regional trade agreements, the wheat imported from some countries benefits from a lower import tax rate. The most rigorous way to proceed is therefore to use an average of import taxes by country of origin (weighted by import values). The CEPII provides this kind of data on "applied tariffs" (MacMap database, see Guimbard et al., 2012). The difference between the MFN tariff and the applied tariff is often small or nil, but may in some cases be considerable. For instance, Mexico's MFN tariff for wheat was 22.39% in 2011, whereas the applied tariff was only 0.71%.

[13] Using the wholesale price in the locality of the port would have been better: using the unit value of imports or exports means assuming that importers' and exporters' margins are stable and close to zero. We used unit values because these data are available for (almost) all countries and all years in the FAOSTAT database. But at country level, data on wholesale prices are usually available (they are collected by market information systems, see Galtier et al., 2014). This is why in section 6b, we recommend estimating transfer and transaction costs by the difference between the average producer price on the main rural markets and the average wholesale price in the locality of the port.

[14] When data on unit values or producer prices were insufficient to enable us to estimate the ttc of wheat in a given country, we applied to this country the average ttc of its category (the categories being: i) exporting countries, ii) landlocked importing countries, iii) non-landlocked importing countries with a high or upper-middle income, and iv) non-landlocked importing countries with a lower or lower-middle income).

[15] The characteristics of the grains whose prices are presented in table 2 are the following:
Maize, US = Maize (US), no. 2, yellow, f.o.b. US Gulf ports
Wheat, US, HRW = Wheat (US), no. 1, hard red winter, ordinary protein, export price delivered at the US Gulf port for prompt or 30 days shipment.
Wheat, US, SRW = Wheat (US), no. 2, soft red winter, export price delivered at the US Gulf port for prompt or 30 days shipment.
Rice, Thai, A1.Special = Rice (Thailand), 100% broken, A.1 Super from 2006 onwards, government standard, f.o.b. Bangkok; prior to 2006, A1 Special, a slightly lower grade than A1 Super.
Rice, Thailand, 25% = Rice (Thailand), 25% broken, WR, milled indicative survey price, government standard, f.o.b. Bangkok.
Rice, Thailand, 5% = Rice (Thailand), 5% broken, white rice (WR), milled, indicative price based on weekly surveys of export transactions, government standard, f.o.b. Bangkok.

[16] On this point, our results converge with the findings of DTB Associates, LLP (2011).

[17] For net exporting countries, the rural markets taken into account are the main rural markets of the producing areas that supply exports. For net importing countries, the rural markets taken into account are the main rural markets of the producing areas that supply the towns where the local supply competes with imports.

[18] For landlocked countries, the estimation of the TTC is rather more complex because there are usually no transactions in the locality of the port (the product is simply in transit). In this case, the TTC must be estimated as the sum of i) the transfer cost between the port and the main locality within the country where imports are sold (or exports are bought), and ii) the difference between the wholesale price in this locality and the average producer price on rural markets that supply this locality (for an example, see FAO, 2014).

[19] The reasons for this are that there is usually i) an upward trend in current wheat prices (an effect of inflation) and, for most countries, ii) a downward trend in the exchange rate of the local currency with the US dollar.

[20] For the specific case of landlocked countries, we also need an estimation of the transfer cost between the port outside and the main point of arrival of imports within the country (or point of departure of exports in the case of net exporting countries). This data is often already available within the country.

[21] This can be illustrated by the case of Zambia (for wheat) in 2012: the quantities exported and imported were extremely low (30 tonnes imported and 90 tonnes exported) and the unit values of imports (UVM) and exports (UVX) were very different (UVX = 133 USD/t and UVM = 567 USD/t). If Zambia had imported 100 tonnes instead of 30 tonnes, the UV for 2012 would have been 567 instead of 133!